Irrigation in India.—The Ashti Tank*.

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This work is situated in the Madha taluka, Sholapur district, about 16 miles southwest of the town of Madha, 12 miles northeast of the important town of Pandharpur, and 15 miles in a direct line from the nearest station of the Great Indian Peninsula Railway. It is proposed to construct a branch line to connect the Great Indian Peninsula Railway at the Barsi Road Station with the town of Pandharpur. T e proposed line passes at a convenient distance from this large irrigation work, and will thus afford facilities for the ready transport of the various grains and produce cultivated to other parts of the country. The project was originally prepared by Captain (now Colonel) C. B. Penny, R. E., in 1869. In 1876, when the great famine in the Deccan was imminent, the prosecution of usefel works upon which to employ the large numbers of people seeking relief from the State was urgently called for, and this work was one of the first undertaken for that purpose. The project was thoroughly revised, the works as executed were designed, and complete plans and estimates were prepared by the author, under the orders of Colonel (now Major-General) C. J. Merriman, R. E., then Chief Engineer for Irrigation. The works were carried on under the author's superintendence.

The total expenditure upon the Ashti Tank works to the 31st of December, 1881, was in round numbers Rs. 4¼ lakhs,[1] of which Rs. 2½ lakhs were expended upon famine and extra-mural labor. Of the remainder, Rs. 1¾ lakh, a considerable amount was devoted to the purchase of materials and stores. The project comprises a storage-reservoir or tank formed on the Ashti, a tributary of the Bhima river, by an earthen dam 12,709 ft. in length, and 58 ft. in maximum height, storing 1,500,000,000 cu. ft. of water, and having an area of water-surface, when full, of 4.18 square miles. Two canals extend from the tank to the banks of the Bhima river; as now designed they are estimated to command a total area of 16,164 acres, and are capable of extension to command a total area of 25,270 acres. The area of the catchment basin is nearly 92 square miles. The geological formation of the locality belongs wholly to the trap series, and appears to be generally of a kind such as would yield a fair portion of the total rainfall for the purpose of filling the tank.

The town of Pandharpur is the station nearest to the site of the tank, at which the rainfall had been gauged prior to 1877, and in preparing this project the annual fall in a period extending over fifteen years was considered in estimating the supply of water available to fill the tank. An abstract of the rainfall registered from 1861 to 1876 is given in the following Table, which shows the total fall in each year, as well as the monsoon fall from June to October inclusive:—

Year.	Total Fall.	Monsoon Fall.
	Inches.	Inches.
1861....	29.91	29.91
1862....	29.75	29.14
1863....	17.07	17.07
1864....	29.29	29.29
1865....	29.71	29.71
1866....	Not available	
1867...	21.29	20.81
1868....	19.40	18.57
1869....	37.21	34.48
1870....	28.65	27.09
1871....	11.49	8.92
1872....	32.99	30.73
1873....	29.47	26.56
1874....	44.70	38.00
1875....	19.92	18.79
1876....	8.09	6.84
Average	24.13	22.59

The monsoon fall can only be considered in estimating the available "run-off," as the rainfall is almost confined to these months. Showers occur generally in May, but in only one year, 1874, was the fall during that month sufficient to produce any appreciable "run-off." Omitting the year 1874, in which the fall was excessive, and the years 1871 and 1876, during which the fall was unusually small, the average monsoon fall was 23.76 in. The available supply of water has been taken at one-fourth of this average, or, say, at 6 in. The rainfall has been gauged since 1877 at Yeoti, a village close to the eastern end of the dam, Plate 2, Fig. 2, and it will be seen from the comparison with the falls registered in the same years at Pandharpur, that in adopting the data afforded by the observations at the latter place, there is probably a safe margin, as the rainfall gauged at Yeoti in each year, except 1877, was in excess of that gauged at Pandharpur, thus:

Years.	Pandharpur	Yeoti.
	Inches.	Inches.
1877	36.66	34.57
1878	38.32	48.20
1879	23.74	30.70
1880	33.62	38.97

Had time admitted, several rain-gauges would have been established and distributed over the cachment area. In the Deccan this is particularly necessary, because the falls of rain are frequently very local, heavy showers sometimes occurring in one part of the cachment, when little or no rain has fallen at another. In the monsoon of 1881 observations were registered at three rain-gauge stations in this cachment basing. The following extract shows how local the heavy falls frequently are:

Months and Date	Rainfall. Yéoti.	Convict Jail.	Modilimb.	Mean of Three Stations.
	Inches	Inches.	Inches.	Inches.
June 5	..	..	0.88	0.29
" 7	0.18	..	1.47	0.55
" 8	0.98	0.98	..	0.65
" 11	0.20	0.51	..	0.24
" 12	0.14	0.15	0.50	0.26
" 29	0.50	0.15	0.68	0.44
July 4	0.58	0.78	0.37	0.58
Aug. 15	0.34	0.31	..	0.22
" 27	1.14	0.65	1.04	0.94
" 29	0.97	0.76	..	0.58
Sep. 11	2.44	2.00	0.93	1.79
" 26	0.67	0.32	0.62	0.54
" 27	2.00	2.17	3.65	2.61
" 30	0.02	..	1.73	0.58
Oct. 3	1.39	1.00	0.28	0.89
" 4	1.05	1.56	0.81	1.14
" 5	0.35	0.24	1.38	0.66

Regarding the question of "run-off," the following observations were made during the same monsoon season, 1881, in the cachment area:

Months.	Rain.	Total quantity of Rain on Cachment Area in Cubic Feet.
	Inches.	
June	3.95	844,250,880
July	1.13	241,519,872
August	3.43	733,108,992
September	6.86	1,466,217,984
October	2.75	587,769,600
Totals	18.02	3,872,867,328

The total quantity of water which flowed into the tank in this period was 689,833,336 cu. ft.

$$\text{Therefore } \frac{\text{"Run-off"}}{\text{Total fall}} = \frac{689,833,336}{3,872,867,328} = 0.18, \text{or } \tfrac{1}{5}\text{th nearly.}$$

The manner in which rain is distributed is a question of importance, only second to that of the quantity of the rainfall. Thus in the monsoon season of 1881 the proportion of the "flow-off" to the total rainfall in each month varied very much, being in July $\frac{1}{100}$, while in September it was rather more than $\frac{1}{5}$, and in October more than $\frac{1}{4}$ of the rainfall during the month. Again, long intervals of dry weather are prejudicial to a fair proportion of "flow-off" being attained, as the land forming the gathering ground dries and attains, in such intervals, increased absorbing power.

The following abstract shows the number of days in 1881 on which the mean fall exceeded ½, ¾, 1, 1½ in. and 2 in. respectively, as well as the number of days when no rain fell, or when it was less than $\frac{1}{10}$ in. at any one of the stations:

Months.	Days on which Rainfall exceeded. ½ in.	¾ in.	1 in.	1½ in.	2 in.	Days of no Rainfall or less than $\frac{1}{10}$ inch.	Remarks.
June.....	3	none	none	none	none	.....	
July.....	1	"	"	"	"	20	
Aug.....	3	2	"	2	"	27	
Sep.....	5	3	2	1	"	25	
Oct.....	3	2	1	none	.....	23	
						28	There was no rainfall in Oct. after the 5th

It may be remarked that falls of less than ½ in., unless such occur on consecutive days, cause very little or no appreciable "run-off."

The "available capacity" of the tank, as calculated, was 1,419,385.000 cu. ft.; but as the canals are now taken off at 5 ft. higher level, this capacity is reduced to 1,348,192,450 cu. ft., and to furnish this quantity a "run-off" of 6.31 in. from the catchment would be required, being somewhat in excess of the quantity available during an average season, thus:—

	Cubic Feet.
Available capacity of the tank.....	1,348,192,450
The "run-off" due to 6 in. or that in an average season.....	1,282,406,400
Difference.....	65,786,050

or 4.87 per cent. of the available capacity of the tank.

The features of the ground did not admit of the capacity being reduced. The level of "full supply" was regulated by the only saddle available for the waste-weir; had that been lowered, the quantity of rock excavation necessary would have cost more than the earth-work required to raise the dam; besides which, there is manifestly an advantage in making the reservoir of large capacity, if it can be done without increased expense; and careful survey and calculation served to prove that, in this case, it would have increased the cost of the work if the capacity of the tank had been reduced. The loss due to evaporation, absorption, etc., was estimated at 4 ft. in depth on half the area at "full-supply" level, thus:—

Loss by evaporation, &c. = 4×116,610,120 = 233, 220,240 cubic feet.

Careful experiments made on the Pashan tank, which has an area of 100 acres, as compared with 2,677 acres—the area of the Ashti tank when full—showed that the total loss from October to May, both months inclusive, amounted to 4.41 ft. in depth. A favorable opportunity occurred on the first filling of the Ashti tank in 1880–81, to observe the actual loss due to the combined effects of evaporation, absorption, and leakage through the sub-soil; in this year, as the canals were not completed, there was no draw-off from the tank, and the loss admitted of accurate measurement.

On the 1st of December, 1880, the area of the water-surface in the tank was 1,412 acres; the loss due to evaporation, absorption, etc., was, in each month, as follows:—

	Foot.
In December, 1880	0.12
" January, 1881	0.40
" February "	0.65
" March "	0.65
" April "	0.95
" May "	1.02
Total	= 3.79 ft.

The tank had commenced to fill in June, 1880, and the water rose in each month until December; and a depth of 3.79 ft. represents the whole loss in the period extending from the 1st of December, 1880, to the 31st of May, 1881. It is not to be expected that during the wet months of the monsoon there would be any serious loss by evaporation, and that estimated, namely, 4 ft. in depth on half the area at "full-supply" level, therefore, appears to be a fair allowance.

The net supply of water available for irrigation may now be calculated from the data given in the foregoing paragraphs, thus:—

	Cubic Feet.
The available capacity of the tank.....	1,348,192,450
Deduct loss by evaporation, etc.....	233,220,240
Net supply available for irrigation.	1,114,972,210

The works included in this project are: the dam, the waste-weir, the outlet works or regulators, the left bank, and the right bank canals.

The site selected for the dam across the valley of the Ashti nala is shown in Plate 2, Fig. 1. The total length of the dam is 12,709 ft.; the breadth at top, which is uniform throughout, is 6 ft.; the breadth at "full-supply" level is 42 ft.; the greatest height of the dam is 58 ft.; the height of the top of the dam above "full-supply" level is 12 ft.; R. L. of the top of the dam, reduced to "mean sea-level" is 1,561.60 ft.; R. L. of the "full supply" is 1,549.60 ft.; and of the sill of the outlet-sluices is 1527.60 ft.; the side slopes above the "full-supply" level are 1½ to 1; the inner slope below "full-supply" level is 3 to 1, and the outer slope 2 to 1. The seat of the dam throughout was cleared of vegetable mould, stones and loose material; all trees and shrubs with their roots being completely grubbed or dug out. The sand and silt were removed from the entire area forming the seat of the dam in the river-bed, and the banks of the river were cut into steps; thus the dam throughout rests upon a sound and firm foundation. There is no puddle-wall in this dam, but a puddle-trench, laid in the natural ground rising 1 ft. above the surface, extends throughout the length of the dam from "full-supply" level near the eastern extremity or left bank to the same level near the western end close to the waste-weir on the right bank. It has been constructed on the centre line, except across the river, where a special arrangement was devised.

The puddle-trench is rectangular in cross-section, 10 ft. in width throughout; it has been excavated through various materials to a com-

*From other selected Papers of the Institution of Civil Engineers.

[1] In this Paper money values have been given in rupees. To admit of ready and approximate conversion into pounds sterling, the figures may be divided by 10; but for persons who require a more accurate estimate, 13 rupees should be taken as the equivalent of £1.—C. T. B.

pact and watertight bed, and then filled in with puddle material, specially prepared. This puddle consists of 2 parts of muram or sand and three parts of black soil; the first layer was prepared wet on the bank, the material being carefully and thoroughly mixed and worked up by men treading with the feet, until the whole became a wet but stiff clay; it was then made into balls kneaded by women, and when so prepared was thrown or dashed into the trench from above, so as to fill every inequality and interstice of the bed. In this manner a layer, varying in thickness up to 12 inches, was completed, and formed a level bed for the reception of the subsequent layers. These latter were put into the trench in a dry state, were then thoroughly saturated with water and worked into puddle in the trench, and on completion were immediately covered in with a dry layer of the mixed material, so as to prevent any tendency to cracking, which would be the inevitable result of exposure to the sun. The trench was completely filled in this manner, and the puddle was throughout raised to a level of 1 ft. above the ground, so as to form a more complete and watertight junction with the earthwork of the dam. In puddling, in layers of 1 ft. in thickness, three men completed 250 cubic ft. per day, including cutting, treading, and covering. Across the river-bed a trench, 5 ft. in width, was excavated along the centre line of the dam, down to the rock, extending 100 ft. into the banks of the river on each side, and connected with the puddle-trench, as shown in Fig. A. This trench was filled with concrete.

The puddle-trench was continued across the river, at a distance of 20 ft. from the concrete wall, and in front of it, that is, on the up-stream side.

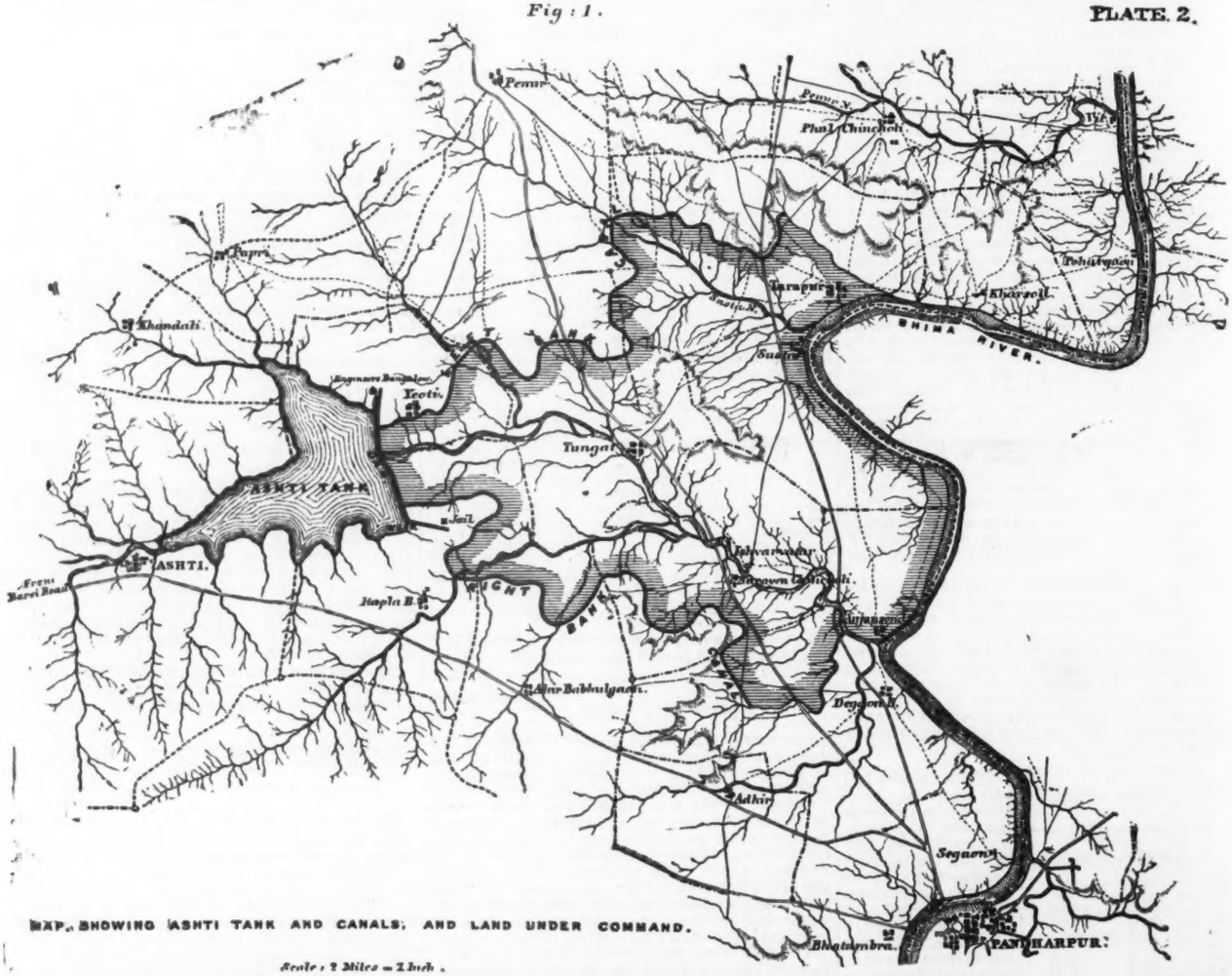
The following mode of procedure was adopted in completing the foundation of the dam in the bed of the river. The puddle-trench and concrete wall having been completed during the dry season, measures were taken to utilize the floods of the ensuing monsoon season to assist in clearing away the sand, silt, etc., from the site forming the seat of the dam in the river-bed. Piers, roughly made of circular wicker-basket work, without top or bottom, filled with rubble stones, were disposed in two rows on the up-stream side of the site; these piers, 4 ft. in diameter at top, 5 ft. at bottom, and 4 ft. in height, were placed about 40 ft. apart. The sand, etc., to be removed was, when opportunity offered, during breaks or periods of dry weather, ploughed, and was thus more readily acted upon by the scouring action of floods. These, when they occurred, flowed with a high velocity through the contracted waterway between the piers, and ultimately caused the removal of a large quantity of the sand from the site of the dam, at a small expenditure.

FIG. A.

A low dam, of dry-rubble stonework, was constructed across the river, about 100 ft. above the site of the dam, to check the ordinary monsoon flow of the river, to cause the silt in suspension to be deposited, and to prevent sand being washed into the parts scoured out by the action of the floods flowing between the piers. This device was fairly successful; the stream flowing through the interstices passed away in a comparatively clear state. The monsoon over, active operations were commenced. First, the sand and all soft materials were excavated from the space between the puddle and concrete trenches, until a hard bed of consolidated clay, known as maan, was reached. This space was then filled with the best black soil, in layers 4 in. thick, which were reduced to 3 in. by watering and rolling. Secondly, a strip 30 ft. in width along the top of the inner slope, across the river, was similarly prepared, the sand and silt being removed down to the underlying bed of maan, and was then filled in with a mixture of three parts of black soil and one part of sand. This was the first part completed, so as to prevent the percolation of water through the sand, and consequent hindrance to the progress of the work in the rear. The ordinary dry-weather stream was diverted through a channel cut in the hard maan on the surface, close to the left bank of the river. With these arrangements the remainder of the area extending to the puddle-trench presenting no special difficulties, was similarly excavated to the underlying maan, and filled in with layers of good black soil.

That part of the site between the concrete trench and the outer toe of the dam, especially on the side near the right bank of the river, was more difficult to deal with, as the bed of maan disappeared, and the foundation of this part consisted of fissured trap rock and hard muram, through which numerous springs of water flowed. These, for the purpose of excavation, were easily kept under; the difficulty lay in filling in the material of the dam

Fig: 1. PLATE. 2.

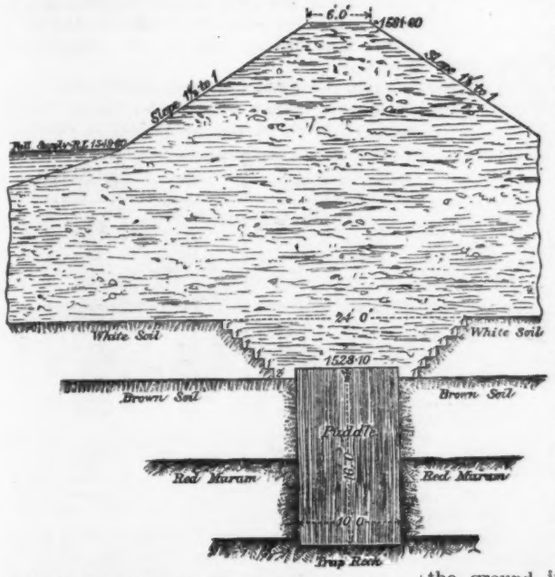


MAP, SHOWING ASHTI TANK AND CANALS, AND LAND UNDER COMMAND.

Scale: 2 Miles = 1 Inch.

After several unsuccessful attempts with ordinary material, a bottom layer consisting of balls of puddle was put in place. The balls were worked one into the other, by men treading the mass lightly but rapidly, and when a layer of sufficient thickness had been deposited, the work was continued in the ordinary way. The only precaution necessary was to excavate wells, about 2 ft. in diameter, down to the bed of rock or muram; water flowed into these, and was constantly baled out, being used for moistening the earthwork in progress. The wells were necessary, because at first the earthwork was spongy in this part, owing to the water having no outlet, and the weight of earthwork was not sufficient to check its flow; however, a height of 5 or 6 ft. was sufficient to

FIG. B.



do this, and when so far completed, the pits were filled in, first by puddling, and then with thin layers of ordinary material well rammed.

The pumps for keeping the foundations dry during the progress of the work were a centrifugal pump, by Gwynne, 6 in. in diameter, worked by a portable 8 HP. single cylinder steam-engine, by Clayton and Shuttleworth, and an ordinary contractor's hand-lift pump; the former was constantly in use, the latter only occasionally.

The only other part of the dam, the foundations of which required special treatment, was that passing through the site occupied by the old village of Yeoti. It was found, on clearing the site of this village, that parts of it were honeycombed with pits sunk to a considerable depth below the surface for storing grain. This is a common practice in villages in India. In would seem desirable not to construct dams on such sites, as although they are frequently situated on high ridges, which, as in this case, offer, at first sight, an alignment apparently economical, yet the special treatment necessary to obtain sound foundations, added to the expense of purchasing the village, would probably nullify any saving, and render a diversion, if feasible, less costly and more desirable. Fig. B shows the arrangement adopted, and all pits traceable in the vicinity of the dam were cleared and filled in.

The white soil forming the upper surface of the site of the village was excavated, the sides being cut into steps (Fig. B), to an average depth of 6 ft., that is, down to the brown soil underlying the white; the upper width of the excavation was 24 ft. This excavated part was filled in black soil in thin layers carefully connected with the puddle.

The general distribution of the material of the dam is shown in Plate 2, Fig. 2 and 3. The central core is formed of the best black soil obtainable. On each side, extending to the surface of the mixed material, brown, reddish, or white earth is used. The shell, or outer part of the dam, is formed of a mixture of about equal parts of black soil and muram; but where muram was difficult to obtain and sand plentiful, the latter was substituted for muram in the mixture. The top of the dam was finished off with a layer of sand ½ in. thick.

The earths or clays used in this work are freed from all large stones, roots of plants, and grass, and surface soil in which roots abound was strictly prohibited. The black soil may be described as a dark grey or brown clayey earth, tenacious and adhesive when wetted; light, crumbling, and intersected by cracks when dry. It is found throughout the Trap area, being a product of the decomposition of the volcanic rock, and every step in the passage from one to the other may often be seen in small roadside sections. The brown and reddish soils are of a clayey nature, but contain admixtures of find sand, kunkur nodules, and thin layers of fine grains of lime. These soils when wetted are adhesive, and form a particularly good material for work of this kind. The white soil consists of finely powdered particles, being of a grayish color, similar to wood ashes; when dry it possesses but little adhesion, and absorbs a large quantity of water: but when wet it is adhesive, and is used in the Deccan as a substitute for martarin the construction of the houses of the poorer classes.

The material for the dam was excavated from the ground in the vicinity, on both sides, but was taken principally from the bed of the tank, no excavation being allowed at a less distance than 150 ft. from the inner, or 200 ft. from the outer, toe of the dam. At this distance the sides of the excavations or pits nearest to, and parallel to, the dam, were arranged in steps of 2 ft. tread and 1 ft. rise. These steps facilitated the carriage of the material, and prevented slips. The objections to excavating pits too close to the site of the dam are obvious; but specifying fixed distances, irrespective of the varying heights of the dam, is opposed to economy, especially when, as in the case of the Ashti dam, the earthwork was executed chiefly by manual labor paid according to the leads. It would therefore be advisable to fix the limits of excavation, that is, the limits within which no excavation of material for the dam is to be made, at a distance from the toe of the dam of not less than three times its height at this part, on the outside, and four times that height on the inner or tank side.

The various soils were laid in the work in layers of 8 in. in thickness, every layer being thoroughly watered, and rolled with iron rollers, each weighing 2 tons 2 cwt., until it was consolidated throughout. Under this process each layer was reduced to 6 in. in thickness. To ensure uniform saturation, the watering was continued during the progress of the work, and again, after the whole layer had been thoroughly rolled and consolidated, the upper surface was saturated, so as to effect the perfect connection of one layer with the other. Each layer was laid to a level surface, both transversely and longitudinally, and great care was taken to maintain this arrangement. The edges of the dam, where it was impossible to work the rollers, were pounded with rammers weighing 30 lbs. each, by men specially trained to this work. One man completed about 500 sq. ft. per day. The iron rollers were drawn by four pairs of bullocks in the "rains," and by three pairs in the dry season; they usually completed an area of 20,000 sq. ft. per day, rolling it three times, which was generally sufficient. During the progress of the work all lumps of earth were broken into small pieces, and for this purpose, as well as for spreading the layer into one of uniform thickness, two men were allowed in a gang of fifty excavators and carriers.

The slopes of the dam are effectually protected, the outer from the action of the weather and heavy rain by the muram and earth.

Experiments made by mixing various portions of soils with sand and muram, and laying them on the slope exposed to the weather, proved that a mixture of about equal parts of soil and the reddish kind of muram (the grey does not answer so well), makes in every way the best and most durable covering. The slope was further protected by being covered with sods of grass (Hari-alil) laid about 3 ft. apart; this was done at the beginning of the "rains," and in time the roots extended until the whole formed a binding and effective covering. The inner slope is protected from the action of waves by being "pitched" or faced with dry stone set by hand, and laid on a layer of coarse muram 12 in. in thickness. The pitching in two thicknesses, 6 and 12 in., extends from a level of 2 ft. below the silis of the outlet sluices or regulators, to within 2 ft. of the top of the dam, that is, 3 ft. above the surface of the estimated highest flood-level in the tank. This height above flood-level in general must depend upon that of the highest waves likely to be generated in the tank, and to ensure absolute safety, the maximum height of the waves should be calculated from the "fetch" when the water in the tank stands at its highest. The case of the Ashti tank is a special one, but ordinarily in large tanks the height of the top of the dam, above the surface of the greatest flood-level in the tank, should not be less than 3 ft., plus the calculated maximum height of waves at that level, the height of the pitching above the surface of flood-level being equal to the maximum height of waves similarly calculated. The stones of the pitching were bedded on the slope, and were laid with their broadest ends downwards; each stone being roughly squared with the hammer, so as to ensure their fitting fairly one to the other, and touching for at least 3 or 4 in., according to the thickness of the pitching, Fig. C. The interstices were then packed with small stone-chippings, and finished off with muram, The uniformity of the plane of the slope was ensured by fixing teakwood templates at 50 ft. apart, the upper surface being flush with the finished surface of the pitching.

Regarding the thickness that ought to be given to the pitching on the inner slope of a dam there appear to be no precise data, but it may be calculated as follows: This thickness depends upon the greatest height of the waves to which the dam is exposed. The maximum height of waves depends on the "fetch," or distance from the weather shore where their formation commence, and may be determined by Stevenson's formula [1]:—

$$x = 1.5 \sqrt{F} + (2.5 - \sqrt[4]{F}),$$

where x = height of wave in feet,
and F = fetch in nautical miles.

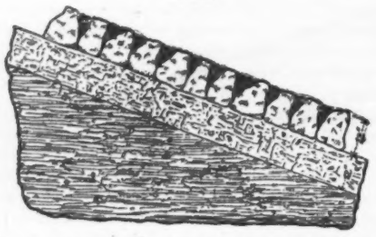
Again, Rankine states, that where an embankment of loose stones is exposed to the action of waves, they must be faced with blocks set by hand, the least dimension of any block in the facing being not less than two-thirds of the greatest height of wave. From these two considerations the thickness of the pitching may be deduced; but in the case of a tank where the pitching is carefully executed,

[1] "The Design and Construction of Harbors," 2d edition, p. 23.

the stones being laid in the manner already described, a less thickness, say one-third of the greatest height of waves, would probably be sufficient.

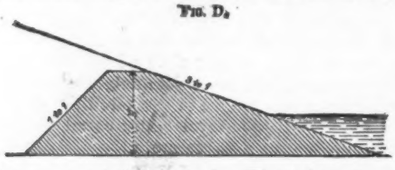
It may be of interest to record how the actual closure of the dam across the river was effected. The stream flowing in the river at the time of the closure, as before described, had been diverted through a small channel

FIG. C.



cut in the maan close to the left bank; the earthwork in the river-bed on both sides had been brought up to a level of 14 ft. above the bed of this channel. The channel, which was 47 ft. in total breadth, was cleared of all silt down to the bed of the maan, on which this part of the dam was founded, in one day. At the same time an earthen bank about 6 ft. in height was thrown across the river about 100 yards above the site of the dam, which bank was closed on the evening of the 23d of February, 1880, thus forming a small tank, which, during its filling, prevented any flow in the river at the site of the dam. At daybreak next morning the work of filling the gap was commenced; balls of puddle material, previously prepared, were filled into the channel through which the stream had been diverted, and raised to a height of 2 ft., being thoroughly consolidated by treading during the progress of the work, then a small section, in line with the inner slope, Fig. D, was raised in 3 in.

FIG. D.



layers to a height of 5 ft. Thus the gap was closed on the 24th of February, 1880. The temporary bank was over-topped on the 26th, but the two intervening days allowed ample time to effect the closure to a height above that to which the water rose; on the 29th the depth of water in the tank was 2.42 ft. The remaining earthwork in the gap was then brought up gradually in 3 in. layers, until it reached the general level of the bank on both sides, when the whole was carried up uniformly in the manner already described.

On the 31st of May, 1880, the earthwork of the dam, in the river-section, was raised to a height of 6½ ft. above "full-supply" level, and the depth of water was on this day 5.95 ft. only. Rain fell on this day and the four succeeding days, and the water rose in the tank as follows:

Date.	Rainfall.	Depth of Water in Tank.
	Inches.	Feet.
31st May, 1881	0.42	5.95
1st June "	0.14	6.02
2d " "	0.07	6.10
3d " "	0.46	10.26
4th " "	2.82	19.29

This was the first storm, and though earlier, than was expected did no damage of any kind.

The earthwork, pitching, etc., of the dam were completed gradually during the monsoon and while in progress it was not feasible to make any observations on the settlement of the dam. This was effected during the monsoon of 1882. On and from June 1, 1882, levels were taken along the top of the dam, no repairs or additions of any kind being allowed; the following were the results in the period of nine months, from June, 1881, to February, 1882, both inclusive:

Length of Dam	Height of Dam	Settlement	Proportion of Settlement to Height of Dam.	Remarks.
Feet.	Feet.	Feet.		
1,000	4	0.04	0.010	
2,000	15	0.16	0.004	
3,000	28	0.28	0.009	
4,000	35	0.36	0.010	
4,200	44	0.53	0.012	
4,300	50	0.73	0.014	
4,400	51	0.43	0.008	On left bank of river.
4,500	56	0.45	0.008	In river bed.
4,600	58	0.43	0.007	" " "
4,700	52	0.23	0.004	On right bank of river
5,000	49	0.38	0.008	
6,000	38	0.06	0.002	
7,000	37	0.20	0.005	
8,000	30	0.09	0.003	
9,000	24	0.28	0.012	
10,000	19	0.03	0.002	
11,000	20	0.16	0.008	
12,000	12	0.04	0.003	

The following statement shows the quantities of the various works included in the dam, and the cost and rate at which each work was executed:

Items.	Quantity.	Rate.	Per	Amount.
		R. a. p.	Cubic Feet.	R. a. p.
Excavation and filling puddle trench	1,914,203	1 14 8	100	36,656 9 3
Excavation for concrete trench	22,500	2 0 0	100	450 0 0
Concrete filling	24,535	12 9 10	100	3,096 6 4
			Sq. Feet.	
Clearing site of dam	909,723	0 1 4	100	727 9 1
			Cubic Feet.	
Clearing site of old village of Yeoti	1,342,000	0 6 0	100	5,032 8 0
Filling in site of dam	404,861	0 8 2	100	2,070 1 10
Excavation of sand, and taking out water from river-bed	390,000	2 4 1	100	8 799 15 3
Filling in ditto	390,000	0 10 4	100	2,526 8 10
Earthwork in dam	21,953,868	0 15 6	100	211,813 8 1
Laying muram on front slope	470,879	1 2 3	100	5,378 2 4
			Sq. Feet.	
Pitching 6 inches thick	220,864	6 0 0	100	13,251 13 5
" 12 " "	501,789	8 0 2	100	40,197 4 0
				330,000 6 5
Contingencies				4,989 9 7
Total rupees				334,990 0 0

The comparative cost of the following earthern dams constructed in the Sholapur district, including all charges on account of works connected with the dam only, that is, such as are included in the above abstract of the cost of the Ashti tank dam, has been as follows:

Name of Tank.	Dimensions of Dam.			Total Cost of Dam.	Rate per 100 Cubic Feet of Superstructure
	Maximum Height.	Length.	Quantity.		
	Feet.	Feet.	Cubic Feet.	Rupees.	R. a. p.
Ashti tank	58	12,709	23,147,400	334,990	1 7 2
Ekruk tank	76	7,000	29,456,740	538,605	1 13 3
Pandharpur tank	44	3,500	6,609,909	85,652	1 4 9

Regarding the cross-section of the Ashti dam, although, as designed, it is amply strong in every way, yet it would be well to consider whether, in works of such magnitude, the adoption of more liberal section would not be advisable.

Plate 2, Figs. 4, 5, 6, and 7, illustrate the form of section at the highest part of three large dams, of which those of the Ekruk and Ashti tank have been completed, and the third, the Pangoan tank works, have been commenced.

In the Ekruk tank dam, which was one of the first constructed by the Irrigation Department in the Bombay Presidency, the breadth at top is unnecessarily great, and is not uniform, but is diminished in proportion to the height, which does not improve the appearance of the dam, is unnecessary under any circumstances, and involves an increased outlay. On the other hand, the top breadth of the Ashti tank dam is too narrow, being only 6 ft. throughout, and this, although sufficient as regards strength, is objectionable for various reasons. A large dam of this kind would warrant, if but for appearance alone, as well as for the convenience afforded by a greater width of roadway, the small outlay necessary to increase the top-breadth sufficiently, and in preparing the plans of the Pangoan tank dam, which was subsequently designed, the author increased the breadth to 8 ft.; but even this appears insufficient for a dam 77 ft. in height, and the author would be glad to see the following generally adopted as the minimum top widths for works of this nature in India: For earthen dams 50 ft. in height and over, the top breadth to be 10 ft.; under 50 ft. in height, 8 ft.

Practical considerations render these increased top breadths desirable. In the course of time settlement must occur in dams constructed wholly of earth, which renders repairs and renewals necessary; in the twelve years since the completion of the Ekruk tank dam, 2½ ft. depth of new material has been added to the top in parts, and this could not have been properly consolidated if compression with a heavy roller had been impracticable, and it is not feasible for bullocks to draw a roller on a high dam having only a 6 ft. breadth of roadway.

Again the change of inclination from 2 to 1, to 1½ to 1, of the outer slope, above "full-supply" level, of the Ashti dam is undesirable. A little moisture in earth, if only sufficient to expel the air from its crevices, appears to increase its coefficient of friction slightly; but any additional moisture acts like an unguent in diminishing friction; the dam is practically water-tight, and when well constructed the material of the outer slope is not sensibly affected by the water in the tank. Any argument, therefore, in favor of making the upper section of an inclination of 1½ to 1, would apply equally to the lower section. Were it urged that the section below "full-supply" level is made with an inclination of 2 to 1, to guard against the possibility of the material be inaffected by the presence of water in the tank, such an argument would undoubtedly apply equally to the part lying between "full-supply" and the level of ordinary floods in the tank. Such floods must frequently stand at this level for a period extending over some days; and if the water would saturate or affect the larger section below "full-supply" level, it would certainly do so in the case of the smaller section lying between that and flood-water level in the tank.

TO BE CONTINUED.

THE Frankfort Water Company has the contract for building the Frankfort, Ky., Waterworks. Dennis Long & Co., Louisville, Ky., are the principal stockholders.

[We publish the above on the authority of F. V. Gray, City Clerk. The Proposals in our advertising columns are dated correctly according to printed form received.—EDITOR ENGINEERING NEWS.

PLATE A.

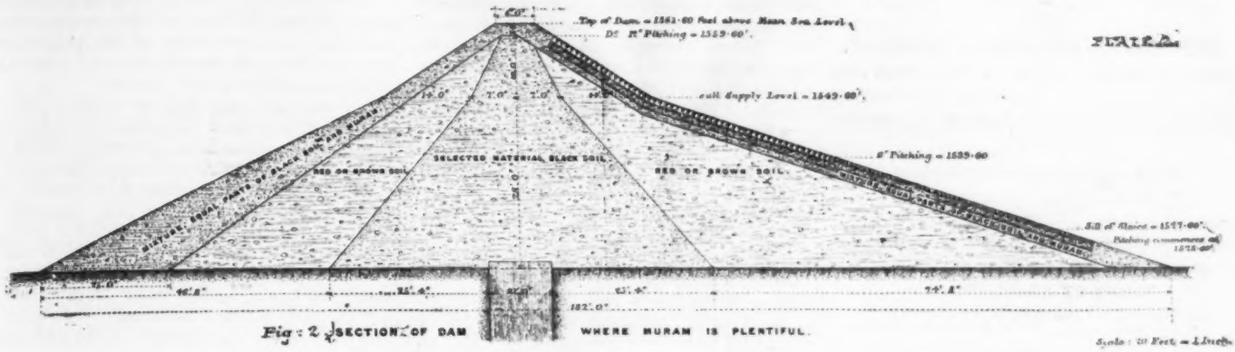

Top of Dam = 1561·60 feet above Mean Sea Level.
Full Supply Level = 1549·60'.
6" Pitching = 1539·60
SELECTED MATERIAL BLACK SOIL
RED OR BROWN SOIL.
Sill of Sluice = 1527·60'.
182'.0"

Fig: 2. SECTION OF DAM WHERE MURAM IS PLENTIFUL.

Scale: 20 Feet = 1 Inch.

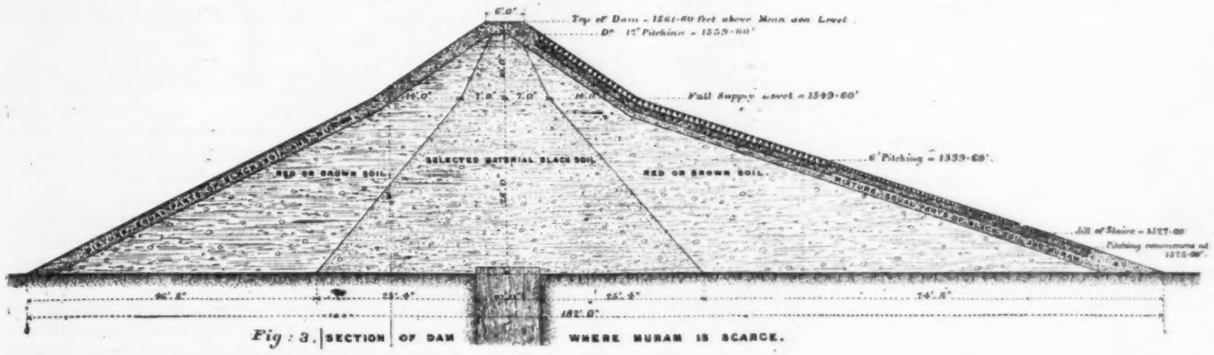
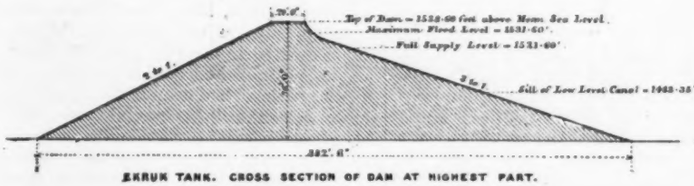

Top of Dam = 1561·60 feet above Mean Sea Level.
Full Supply Level = 1549·60'
6" Pitching = 1539·60'.
SELECTED MATERIAL BLACK SOIL
RED OR BROWN SOIL.
Sill of Sluice = 1527·60'
182'.0"

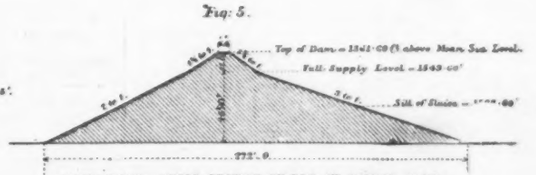
Fig: 3. SECTION OF DAM WHERE MURAM IS SCARCE.

Fig: 4.


Top of Dam = 1538·60 feet above Mean Sea Level.
Maximum Flood Level = 1531·60'.
Full Supply Level = 1531·60'
Sill of Low Level Canal = 1493·35'.
332'. 6"

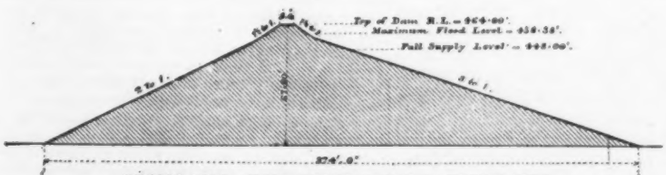
EKRUK TANK. CROSS SECTION OF DAM AT HIGHEST PART.

Fig: 5.



ASHTI TANK. CROSS SECTION OF DAM AT HIGHEST PART.

Fig: 6.

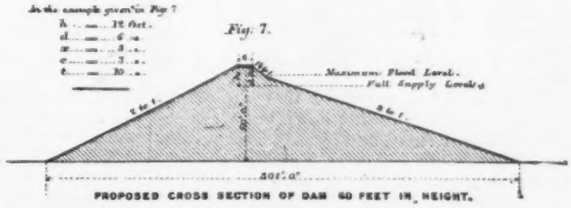


PANGOAN TANK. CROSS SECTION OF DAM AT HIGHEST PART.

In the example given in Fig 7

h	12 feet.
d	6 "
x	3 "
c	3 "
t	10 "

Fig: 7.

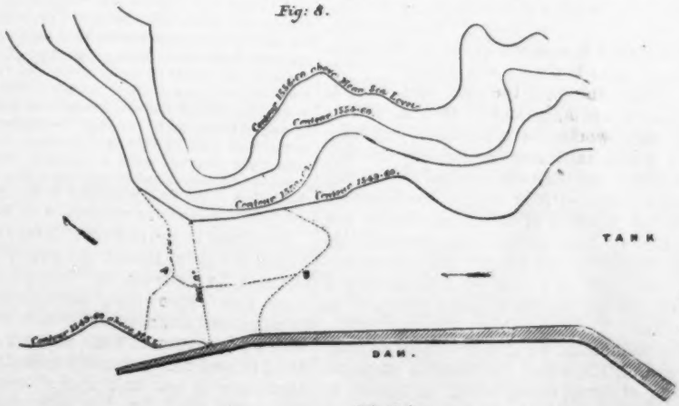


PROPOSED CROSS SECTION OF DAM 60 FEET IN HEIGHT.

CROSS SECTIONS OF DAMS IN THE SHOLAPUR DISTRICT.

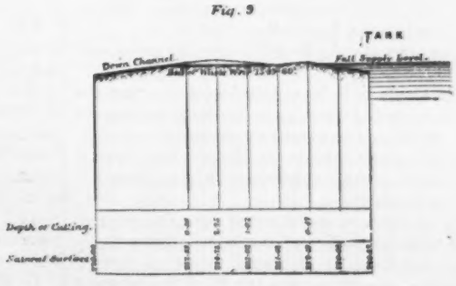
Scale: 60 Feet = 1 Inch.

Fig: 8.



PLAN.

Fig. 9



SECTION ON A.B.

WASTE WEIR

Horizontal Scale, 200 Feet = 1 Inch.

Vertical Scale, 20 Feet = 1 Inch.

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The Institution of Civil Engineers.

In our issue of May 24, 1884, we referred to an editorial in *Engineering*, relating to the attempt of Alex. R. Birnie, M. Inst. C. E., to obtain an expression of opinion upon the right of non-resident members to vote for officers of the Institution by letter-ballot.

Mr. Birnie issued 3,550 circulars to members and requested that replies be sent to the Institution, and addressed a letter to that body explaining his position in the matter and requesting a report upon the results of his efforts.

The Council has answered this request by most unmercifully sitting down upon the author of the circular, and by a formal resolution, regards his action as irregular and objectionable, and declines to acknowledge the expression of opinions so obtained upon *ex-parte* statements.

So endeth the first chapter; and, from a parliamentary point of view, the Council is doubtless right in its decision. But to an American, with all the boundless rights of the ballot-box at his disposal, it does seem odd that over 70 per cent. of an organization so numerous and powerful as the Institution of Civil Engineers of England should have no voice in the choice of their officers.

The Council, in its resolution, states that the By-laws define the proper course to be adopted if it be desired to obtain an expression of opinions upon any subject relating to the Institution, such as the enactment of any new By-law or Regulation.

These By-laws specify that upon the requisition in writing of any twenty corporate members the Council is bound to call a special meeting, specifying the nature of the business to be transacted; that this call shall be sent to all members within the United Kingdom at least seven days before the time of meeting, and this special meeting shall be devoted to the consideration of this business alone.

Herein alone lies the remedy for this mark of English conservatism and old-time methods as exemplified in the requirement of a personal ballot from a widely scattered constituency. If Mr. Birnie can find a sufficient number of members, with enough interest in the matter, to journey to London and vote, they can have their way, if in the majority. If not the present arrangement must remain and the 300 London members appointed the representatives of the whole 4,000 men now on the rolls. The only trouble is that the members living within seven days of London must decide for the great number of non-residents who mainly object to the present form of election.

The Kerr Pavement.

On Fifth Avenue, between 32d and 33d streets there is being laid a pavement which is new to this country, although some 500,000 square yards of it have been put down in Paris, and 800,000 in London. In principle it is a concrete pavement covered with a wooden cushion or carpeting.

The description of the process by which it is laid is as follows: The road-bed is first covered with a 6 in. coating of concrete composed of Portland cement and broken stone, finishing off with a top dressing of Portland cement and fine gravel or sand. Upon this are laid blocks of common red pine of the size commonly used in Nicholson pavement. Between these blocks are left spaces of about ¼ of an inch wide into which is poured bitumen or asphalt for an inch in depth. This fastens them to the foundation of concrete and to one another. After this has set, the crevices are filled completely with Portland cement, and the whole is covered with fine sharp gravel which is ground into the pores of the wood and forms a protective coating. The wooden blocks are previously treated with creosote to protect them from decay and to prevent them from swelling when wet. A space of 3 in. is also left between the wooden blocks and the curbing on each side as a species of expansion joint. The sole right to lay this so called "Kerr" pavement in the United States is held by Mr. J. H. Gafney, 127 Broad St., New York, who has obtained permission from the Common Council to pave the section of Fifth Avenue mentioned, as a piece of practical advertising. The work is under the personal direction of Mr. Stromquest of London, Eng., who has had considerable experience in laying this species of pavement. His method is very similar to that given above. The concrete which serves as a foundation is composed of 1 part Portland cement, 2 parts coarse gravel and 4½ parts broken stone. The cement is a brand manufactured by Kuhlmann & Meyerstein of Hanover, Germany, the American agency of which is held by Baetjer & Meyerstein, No. 5 Dey St., New York. The wooden covering is prepared by sawing 3 in. planks of Norwegian pine into 6 in. lengths and dividing these into blocks of about 9 in. in length. These blocks are then placed so that the grain of the wood is vertical, making a floor 6 in. thick.

The actual first cost of this pavement is somewhat more than that of Belgian blocks but the plan upon which it has been put down in Paris is that known as the annuity system, in which the company contracts to lay the pavement and keep it in repair for eighteen years for an annuity of about one dollar per square meter. This annuity was computed on a basis which should render the expense to the city one half the cost of maintaining a pavement for the eighteen years previous to the contract.

In this connection we give the statistics compiled by Col. Haywood, the London engineer in charge of street construction, in regard to the security of footing afforded by different kinds of pavement. As a result of observations extending over sixty days he found that a horse would travel 117 miles on asphalt, 134 on stone and 446 on wood pavement before falling, and that falls occurring on wood pavement were by far the least serious.

The Corinth Canal.

The *Bulletin du Canal de Corinthe*, of June 30, 1884, contains the annual report upon that work made by Gen. Türr, at the meeting of June 28, 1884, in Paris. From it we make the following extracts:

The general progress of the works promises its completion in 1886; in the Calotte, or English Cut, the tunnel headings are within 1,070 ft. of each other, and 33 shafts are open; the material removed per month from this summit cut amounts to 80,000 cu. yds. The number of workmen employed is 1,682; the total population connected with the enterprise is 2,300. The two 300 H. P. Marine dredges were detained at Lyons by low water in the Rhone, but the first reached Kalamaki on June 18th, and the second was expected in the first week in July.

The total expenditures to date are as follows:

Excavation, jetties, work-shops and buildings	3,500,000 ft.
Material and supplies to the work	3,500,000 "
Material, etc., deliverable within the year	1,500,000 "
($1,700,000)	8,500,000 ft.

The Panama Canal.

Rear Admiral Cooper has reported upon the present conditions and future prospects of the Panama Canal, and from the advance sheets of his report we make the following abstracts:

Admiral Cooper says that although no great amount of work had been done on the canal itself all the preliminary surveys and soundings had been made, the route had been almost entirely cleared of its tropical growth by the Puerto Bello Indians, large quantities of supplies provided, cottages and barracks for the employes erected in healthy, elevated localities; hospitals established, and, in his opinion, such liberal provision had been made for all possible emergencies that "this careful preparation for the great undertaking strengthens his belief that the canal will be ultimately finished." As to the possibility of this result at the time estimated—1888—he says:

"The whole undertaking is so gigantic that one can scarcely believe that it will soon be finished; but I am impressed with the fact that the French are thoroughly in earnest, and that if they fail to finish the canal on account of funds the work done by them will be so extensive as always to give this route great advantages over any other. After all, the completion of the canal is a question of money, for the undertaking offers no insuperable engineering difficulties; but the enormous cost, which can hardly be estimated, and the long time which an investor in the enterprise must wait for returns upon his money, may deter capitalists from taking the stock, and thus the company may be crippled and the work brought to a close."

"The lowest estimated cost of the canal is $120,000,000 and to pay the expenses of working the canal and a reasonable dividend to investors the amount received for tolls per annum should be at least 10 per cent. of the cost, or about $1,000,000 per month. The cost of the canal will probably be much more than the above estimate, and it does not seem probable that there will be commerce enough passing to and from the Pacific ports by way of the canal to pay this enormous sum, at least in the near future. One fact, however, is certain, that even if the present canal completely fails, still if the canal is ever completed along this route, the credit of the design of the enterprise and of its energetic commencement will always be accorded to M. de Lesseps."

In regard to the epidemic fevers supposed to follow the upturning of the soil of the isthmus swamps, he believes the trouble will be less from this cause than anticipated. At the Panama end sickness did follow, but at Colon, with a population of 9,000, and miles of swamp filled in and very extensive dredging done, the death-rate is not half that of two years ago. The canal work has the advantage over the Panama R.R. construction of possessing extensive hospital accommodations and facilities for the rapid transit of patients to these hospitals. The hospital outlay is about $1,000,000.

Admiral Cooper states that the justly famed machinery used in excavating the Suez Canal

has been fairly excelled by the dredges of the American Contracting and Dredging Co., and those built by Osgood & McNaughton, of Albany, and proposes to give heliotypes of these machines in his report.

Chimney Construction.

A correspondent at Atlanta, Ga., failing to find the information desired in any published books, wishes to hear through ENGINEERING NEWS concerning the cross-section, at bottom and top and height of chimneys, to realize the best results from steam boilers, etc.

[The answer to this question depends upon the amount of coal to be burned by the furnaces for which the chimney is to furnish draft; and the only general answer which can be given is one in terms of the horse-power of a boiler, from which our correspondent, knowing the rating of his boilers, can work out the dimensions for the corresponding chimney.

An average boiler requires the consumption of 4lbs. of coal per hour per horse-power, nominal rating. Allowing an excess of 100 per cent. over the amount of air required for theoretically perfect combustion, one pound of coal in burning produces about 630 cu. ft. of gas at a temperature of 570° Fah., the maximum temperature allowable in an ordinary chimney. An excess of 100 per cent. is the greatest that need ever occur in practice.

It is evident then that

$$V = \frac{4 \times 630 \times H.P}{3600} = .7\ H.P.$$

in which V represents the volume of gas passing through the chimney per second, and $H.P.$ is the nominal rating of the boiler in question. Also.

$$V = F \times S \text{ and } F = \frac{V}{S}$$

if F is the cross section of the chimney and S the velocity of the gases at that cross section. The authorities give 15 ft. per second as the limiting value of S, so that

$$F = \frac{V}{15}$$

and by substitution

$$F = \frac{.7\ H.P.}{15} = .046\ H.P.$$

This equation gives the value of F, the mean cross section of the chimney, *i.e.* the area of the cross section at a point midway between top and bottom.

No rule is given as to the rate at which this cross-section should decrease, but an average of fourteen chimneys now standing gives an inside taper of $\frac{1}{30}$th.

To determine the height Prof. Thurston's rule may be followed, which is: "Add one to the number of pounds of coal to be burned per square foot of grate surface per hour; divide by two, and square the quotient. The result is the height of the chimney in feet."

Or, using the diameter of the chimney previously deduced, we have

$$H = \frac{2\left(h_1 + h_2\right) + 1.265}{1 - \frac{1.1012}{D}} \qquad (1)$$

in which H. is the height of chimney in meters (3.28 feet), h_1 and h_2 are the resistances to be overcome in drawing the air through furnace and flues respectively, expressed in the height of a column of air in meters, and D is the diameter of the chimney in meters.

With the data above assumed

$$h_1 = 6, \text{ and } h_2 = .28\frac{l}{d}$$

l being the length of the flues and d the diameter of their total cross-section which should be equal to the cross-section of the chimney. If the chimney is circular.

$$D = \sqrt{\frac{4F.}{3.1416}}, \text{ if Square, } D = \sqrt{F}$$

Since in these two equations F is in square feet D will also be in feet; reducing it to meters by dividing by 3.28 and substituting in equation (1) together with the valves of h_1 and h_2 above determined, the value of H, the height of the chimney in meters, is obtained.

To reduce the height H from meters to feet, multiply by 3.28.

The thickness of masonry at the top in large chimneys is generally about 10 in. and the ratio of height to outside diameter of base varies from 10 to 14. [ED. ENG. NEWS]

The Excavation of a Great Cut in France.

CONDENSED FROM THE *Génie Civil* FOR ENGINEERING NEWS.

The railroad from Saumur to Chateau-du-Loir, after leaving the valley of Loire crosses an elevated plateau by a cut 1640 ft. long and with a maximum depth of 62½ ft.; the cubic contents equalled 274,500, cu. yds.

The material belongs to the tertiary period, the eocene; it is made up of a bed of clay enclosing large boulders of a pudding-stone formation, lying in distinct strata, about 17 ft. thick; under this is a bed of white clay, 29½ ft. thick, traversed by small veins of sand; beneath this again is sand.

The method of removal adopted was as follows: A gallery or tunnel was driven into the cut at its base, and this tunnel was connected at intervals with the surface of the cut by vertical shafts, located on the axis of the cut. These wells were then enlarged from the top by giving them a funnel shape, and the material thrown directly into the cars placed beneath, at the bottom of the shaft. The tunnel was driven from both sides.

The tunnel was timbered as in a mine; two posts and a cap of oak 10 × 10 in., spaced about 5 ft. apart, with lagging of poplar planks 10 × 1½ in. and 6½ ft. long. The gallery was $7\frac{9}{10}$ ft. high and 11½ ft. wide in the clear.

While the tunnels were being driven, the wells were also sunk. At the bottom of the wells the caps of the tunnel-timbering were tied together longitudinally by braces spaced 3½ ft. apart, thus forming a kind of box and strengthening the upper part of the gallery; four of the covering planks covered this space.

As soon as the wells were finished and the tunnel driven the removal of the material commenced. The workmen began by breaking away the earth at the top of the shaft by bars, and throwing it into the opening. As soon as the slope of the cone thus formed became too flat to permit the free motion of the debris, the cone was deepened so as to present a steeper pitch. One man in the gallery was all that was required to regulate the fall of the earth into the cars. At this cut only two wells were worked at a time; this was sufficient to furnish a cube of 600 cubic yards daily. By this method timber was saved, and the tunnel advanced by re-using that from the portion of the cut finished.

The train of empty wagons was drawn in by three horses, and the horses and their driver were prisoners in the tunnel heading while the filling was going on, but as no relays of horses were thus required, an interval of rest was afforded. The loaded cars descended by gravity to the dump by reason of the grade of the road.

In this method of excavating, it is advantageous to have cars as large as possible so that they may be less frequently moved; at the cut in question the cars contained 4½ cu. yds, and ran upon a track of 5 ft. gauge. As each movement of a car corresponds to a stoppage in the excavation, as soon as the bed of sand was reached the Engineer, to avoid the loss of time from this cause, put a stop-valve at the bottom of the well.

The valve was made by placing upon a timber frame-work a sheet-iron cylinder 2 ft. in diameter, closed at the bottom by an iron door, like that used on a beton-mixer. This door moved horizontally in guides and was pivoted at one side.

When the successive funnels met at the top a series of cone-like excavations of great width were presented and it only remained then to cut down and remove the walls of earth lying between the cones.

The cost of the timber for 1200 ft. of tunnel, including the timbering of the shafts, was $782,00.

The manual labor and expense of driving the tunnel amounted to $1.83 per lin. ft. The total expense was as follows:

Timber, for tunnel and shafts	$ 782.00
Labor and tunnel advance @ $1.83×1200	2,196.00
Sinking 4 wells at $20. (100 frs.) each	80.
	$3,058.00

Dividing the total cost by the contents of the cut, 274,500 cu. yds. we have as the cost per cubic yard about $1\frac{1}{10}$ cents (0.fr.074 per cubic metre.)

Torpedo Experiments.

Some recent experiments of Admiral Jaurés of the French navy with torpedoes have resulted very satisfactorily to those who claim a high degree of efficiency for this class of naval engines.

When starting on a voyage from Toulon to Lisbon with a small fleet, the admiral took with him two torpedo boats, Nos. 63 and 64. The plan of the test was simple, the torpedo boats were to do their best to reach the ships, the ships were to avoid and thwart them if possible. Everything favored the latter, the night was calm, the moon full, the ships provided with powerful electric lights, and their officers and lookouts informed of the hour of attack. In spite of all this, torpedo boat No. 64 which appoached the squadron in front, was not discovered until within 1,000 yards of the vessels, and moving at a speed which would cover that space in a little over one minute. When it is remembered that these boats discharge their torpedoes with absolute certainty at 300 yards, and with fair chances of success at 400, it will be seen that pretty quick work would be required of the crew of an iron-clad, even under the favorable conditions of the experiment, to destroy the torpedo boat before having their own vessel sunk under them. In rough weather or on a dark night, three or four boats of this description would keep a hostile cruiser well occupied in defending herself.

The English protect their iron clads from attacks of this nature by steel netting. It is certain that these retard the speed and materially interfere with the manœuvres of the vessel to which they are attached, and leave it uncertain as to what extent they defend her.

A New Aligning Instrument.

At the July meeting of the Cleveland Engineers' Club, a paper entitled "An Aligning Instrument," was read by H. F. Dunham, and ably discussed by Professor Robinson of Columbus, Mr. Latimer, and others. The instrument referred to was recently designed by Mr. Dunham. It is intended for use in determining the position of preliminary lines in field work, and, while not too large for the pocket, secures with sufficient accuracy results heretofore attained by heavy instruments. By its use the observer is enabled to determine the position of a line between two points when neither of the points can be seen from the other, and also to compare the slope or grade of the country passed over with that lying in the foreground.

THE authorities of Berlin are trying tile pavements for the streets. The tiles are moulded into blocks 7.8 in. square and 3.9 in. thick, and are impregnated with bituminous products up to 20 per cent. of their volume. They are laid on concrete 6 in. thick. The spaces between them are filled with hot tar.

PERSONAL.

GUY H. ELMORE and GEO. R. BAUCUS, Civil Engineers, have bought the patent rights of the Durham House Drainage System for the Western half of Missouri and Kansas and have opened an office in Kansas City, Mo.

SAMUEL M. GRAY, City Eng. of Providence, and CHAS. H. SWAN, C. E., returned on July 5th from their European tour of inspection of sewerage systems and sewage disposal. They have been absent four months and in that time made the tour already outlined in this journal. A full report of their investigations is promised in September next.

MR. C. C. CHANDLER was appointed Chief Engineer of the Hannibal and St. Joseph Railroad, vice MR. T. L. DUNN, resigned to accept another position. The appointment took effect on July 10th, and those having to do with new works, and the repairs or renewals of bridges, will report to and receive instructions from MR. CHANDLER, and be governed accordingly.

BENJAMIN F. LARUE has resigned the position of City Engineer of Jackson, Mich., on account of the inadequate salary, $1,000 per year, and has opened an office as Civil Engineer and Surveyor. His specialties are location of railroads, division of property, and general land surveying. Leveling and surveying for sewers and drains. Plans and estimates of bridges.

TURNOUTS:

Exact Formulæ for their Determination, together with Practical and Accurate Tables for Direct use in the Field.*

BY W. B. PARSONS, JR., C. E., ROADMASTER NEW YORK AND GREENWOOD LAKE DIVISION, ERIE RAILWAY.

The aim of these articles is to present in a compact and practical form a set of formulæ sufficient to solve all problems in turnout location, and also to give accurate tables easily understood from which the required dimensions for all ordinary cases can be readily taken without recourse to mathematical work. It is thus designed to meet the requirements of the Engineer, Roadmaster and Foreman.

The author is indebted to Mr. Wm. R. Storey of Rochester, N. Y., for his careful assistance in the preparation of the tables.

The arrangement by which one track leaves another is called a turnout, and it consists of a frog, the rail leading to the frog, the opposite rail, which together are generally called lead rails and some device connecting these lead rails with the main track rails. When this device is part of the lead rails and carries them out to a point of tangency on the main rails, it is called a "point" or "split" switch, but when there are two rails common to both turnout and main track, so that they can become a part of either, it is called a stub switch, and the common rails are variously called, "moving" switch or "swing" rails. One end of these rails rest on the head block and they are moved together by appropriate mechanism. This end is called the "toe," and the "throw" of the switch is the distance the "toe" moves on the head block when passing from main rail to that of turnout. The other end is called the "heel." The "heel" is fixed and is the origin of the turnout curve, or where it becomes tangent to the main track. The moving rail therefore forms the part of the turnout curve between the head block and origin.

The frog angle is the angle contained between the sides of the V shaped portion or tongue where the main or turnout rails intersect; one side of the frog forms part of the main rail, the other part of the turnout, and is tangent to the turnout curve. The frog number is the ratio of the width of the heel of the frog to the bisecting line.

A single throw switch is a single turnout from main line to either right or left. A three-throw switch is a double turnout from main line to both right and left. In this case there are two frogs, which generally are of the same angle, although this is not necessary. A cross-over or crossing is a means of passing from one track to another parallel to it, and consists of a turnout from each track and a piece connecting them between the frogs. The frogs should be of the same angle. When the parallel tracks are straight this connecting piece is also straight, but is curved when the parallel tracks are curved. In the special case however when the space between the tracks is very great the frogs may be joined together by a reversed curve of assumed radius.

The principle on which these calculations are based can be briefly stated as follows, and readily understood by reference to Fig. 1. One side of the frog is part of one of the main track rails; consider the other sides prolonged until it intersects the opposite rail. We then have two lines intersecting, whose intersection angle is equal to the known frog angle. Now the simplest arrangement to join these two lines is by a regular curve which must, by nature of the case become tangent to one of them at the frog point. Hence the point of the curve on one tangent is fixed, and the length of the tangent, *i. e.* the side of the frog prolonged depends on the frog angle and gauge of track, and so of course do the other functions of the curve, as length, radius and degree. One point of tangency being at the frog point, the other P. T. on opposite main track rail is distant from the point of intersection the length of the tangent. This is the heel of the switch. The distance from the heel to the frog point measured on the main track can be easily found for any frog angle and gauge of track. This distance is called the total length of lead. In the case of a "point" switch, the "toe" of the switch point is tangent to the main track rail and hence is to be placed at the heel of the switch, viz. distant from frog point the total length of lead. With a stub switch it is necessary to know how much of the curve is to be required for the moving rail, or to determine location of head block. This depends on throw.

Taking a rail longer than that required by formulæ and spiking it down with the exception of the necessary length for moving rail, when it is thrown, it will be found that the rail has been sprung into an arc of the turnout curve, whose origin is at the heel of the switch where spiking stopped.

Hence it is seen that the length of the lead depends solely on frog angle and gauge, and that the position of the head block or length of the moving rail is determined by the same considerations together with the throw.

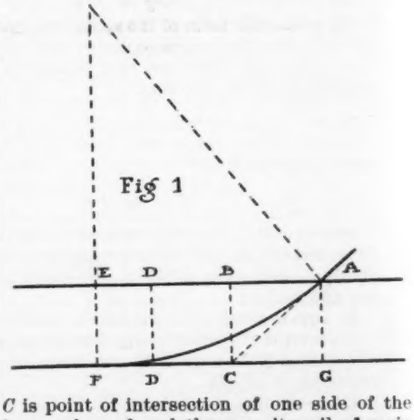
We will take up the several cases in the following order:

Turnout from straight line.
Turnout from outside of curve.
Turnout from inside of curve.
Cross-over from straight parallel tracks.
Cross-over from curved parallel tracks.
Double turnout with equal frogs.
Double turnout with unequal frogs.

TABLE No. 1.—Dimensions of Single and Double Turnouts.

Frog Number	Frog Angle	Head Block to Frog Point	Length of Moving Rail	Total Lead Heel to F. Point	Tangent	Radius of Turnout Curve	Degree of Curvature	Head Block to Crotch Frog	Angle of Crotch Frog	Number of Crotch Frog
		FT. IN.	FT. IN.	FT. IN.	FT.	FT.		FT. IN.		
5	11° 25′ 16″	33 1	14 0	47 1	23.78	235.42	24° 31′	19 4 1-2	16° 08′ 19″	3.527
5 1-2	10° 23′ 20″	36 4 1-2	15 5	51 9 1-2	26.11	285.85	20° 13′	21 3 1-2	14° 40′ 56″	3.881
6	9° 31′ 36″	39 8 1-4	16 9 3-4	56 6	28.45	339.00	16° 58′	23 2 1-2	13° 27′ 57″	4.235
6 1-2	8° 47′ 51″	43 0	18 2 1-2	61 2 1-2	30.79	397.86	14° 26′	25 1 1-2	12° 26′ 07″	4.589
7	8° 10′ 16″	46 3 3-4	19 7 1-4	65 11	33.13	461.42	12° 27′	27 0 3-4	11° 33′ 04″	4.943
7 1-2	7° 37′ 41″	49 7 1-2	21 0	70 7 1-2	35.47	529.69	10° 50′	28 11 3-4	10° 47′ 02″	5.297
8	7° 09′ 10″	52 11	22 5	75 4	37.81	602.67	9° 31′	30 11	10° 05′ 43″	5.651
8 1-2	6° 43′ 59″	56 2 3-4	23 9 3-4	80 0 1-2	40.16	680.35	8° 26′	32 10	9° 31′ 03″	6.005
9	6° 21′ 35″	59 6 1-2	25 2 1-2	84 9	42.51	762.75	7° 31′	34 9 1-4	8° 59′ 30″	6.359
9 1-2	6° 01′ 32″	62 10 1-4	26 7 1-4	89 5 1-2	44.85	849.85	6° 45′	36 8 1-4	8° 31′ 10″	6.713
10	5° 43′ 29″	66 2	28 0	94 2	47.20	941.67	6° 05′	38 7 1-2	8° 06′ 40″	7.067
10 1-2	5° 27′ 09″	69 5 1-2	29 5	98 10 1-2	49.55	1038.19	5° 31′	40 6 1-2	7° 42′ 36″	7.420
11	5° 12′ 18″	72 9 1-4	30 9 3-4	103 7	51.90	1139.42	5° 02′	42 5 3-4	7° 21′ 35″	7.774
11 1-2	4° 58′ 45″	76 1	32 2 1-2	108 3 1-2	54.25	1245.35	4° 36′	44 4 3-4	7° 02′ 26″	8.128
12	4° 46′ 19″	79 4 1-2	33 7 1-2	113 0	56.60	1356.00	4° 14′	46 3 3-4	6° 44′ 51″	8.482
12 1-2	4° 34′ 52″	82 8 1-4	35 0 1-4	117 8 1-2	58.95	1471.35	3° 54′	48 3	6° 28′ 40″	8.835
13	4° 24′ 19″	86 0	36 5	122 5	61.30	1591.42	3° 36′	50 2	6° 13′ 43″	9.189

FIRST CASE.—TURNOUT FROM TANGENT.



C is point of intersection of one side of the frog prolonged and the opposite rail of main track. The intersection angle *ACG* evidently being equal to the given frog angle. The problem then is to join these two tangents *FC* and *AC* with a regular curve.

In triangle *ABC* where angle *BAC* = frog angle and *CB* = gauge, find *AC* and *AB*.

But *AC* is tangent or *T* and frog angle is intersection angle or *I*, then:

$R^1 = T \cot \frac{1}{2} I$ will give radius of outside rail and $R = R' - \frac{1}{2}$ gauge will give radius of turnout curve. (1)

$AE = EB + BA = T + BA$ = distance from heel of switch rail to point of frog. (2)

To find length of moving rail *ED* or *FD* for a given throw, *i. e.* that portion which should be left unspiked so as to be free to move, we have to calculate what length of curve is necessary to produce tangent deflection = given throw. Done by formulae.

$$C = \sqrt{\frac{d \cdot 50}{\sin D}} \qquad (3)$$

In which *C* = length of moving rail required *D* = deflec. angle, and *d* = twice throw.

Results deduced by these formulae for various frog numbers will be found in table No. 1.

TO BE CONTINUED.

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CORRESPONDENCE.

Founding of Cast-iron Pipe.

Special Correspondence Engineering News.

NEWPORT, KY., July 14, 1884.

EDITOR ENGINEERING NEWS:—Referring to the article of Mr. McElroy in your issue of 12th, inst. Mr. McElroy professes not to be aware that cast-iron pipe less than 12 in. diameter are made in vertical moulds and in dry sand. We will give Mr. McElroy $500 to prove that there is any first class foundry in the country that makes them in any other way. Let Mr. McElroy specify or shut up. No man has any right to make statements in a public print that a little investigation would show him to be untrue in almost every particular.

CINCINNATI & NEWPORT IRON & PIPE CO.

The Efficiency of Screw Drivers.

Special Correspondence Engineering News.

PITKIN, COLO., July 10, 1884.

EDITOR ENGINEERING NEWS:—A question came up here regarding the relative power of two screw drivers of different lengths. One argument was in favor of the long screw driver (2 feet in length) as giving more power in proportion to its length, while the other argument was in favor of the screw driver (8 inches in length) doing the same work (provided that the bit and handles of both were the same size the only difference being in length) if it was sufficiently strong and had sufficient room to apply power equal to that used with the long screw driver. The power of a screw driver is at right angles to its axis and increasing its length will not increase its leverage. It is of course a lever, and all things being equal except length, the argument in favor of the short screw driver was accepted, after a practical test. Can any of your readers throw light on this subject?

Yours truly,

R. A. SKUES,
U. S. Dy. Min. Sur.

Convenient Specifications.

PITTSBURG, PA., JULY 14, 1884.

EDITOR ENGINEERING NEWS:—Allow me to commend to the engineering profession generally the admirable form of the specifications issued by the Sewer Department of the city of Buffalo, New York. I refer more particularly to the convenient size of the same, *octavo* 6 in. by 9 in. and stitched together in book form.

Nearly every individual, company and corporation issuing specifications use a different size and form of paper, some which I have seen, resembling when opened the "blanket sheets" of the newspapers of some of our large cities.

If all specifications were gotton up the size mentioned, namely, 6"×9", the number of pages varying with the length, and in cases where a railroad company issues a number of specifications, they could be easily bound together, thus forming a convenient form for filing away and easy to get at when needed in case of reference, much more so than when printed on various sized paper and thrust in pigeon holes.

But the worst abomination is the specifications printed on long, separate pieces of paper and these fastened together at the top and then rolled up. Anybody that ever had occasion to use these will know whereof I speak without further elucidation.

This seems to be the age of uniformity in all matters both large and small. This may be a small one to "harp" about, but I am sure that contractors and others will call those engineers blessed who will follow in the footsteps of the Sewer Department of Buffalo.

Respectfully.

Cement Pipe for Sewers.

NORWICH, CONN., JULY 8, 1884.

EDITOR ENGINEERING NEWS:—Quite awhile ago there was some correspondence in your paper relative to the merits of cement pipe for sewers and drains.

I suggested that if makers would give us specifications under which it should be made and tests by which its quality could be determined, it would do much to relieve an apparently unreasonable prejudice against it. No response appeared.

A very large proportion of the pipe used for sewers and drains in Norwich during the past ten years has been cement pipe.

I have yet to receive positive evidence that any of it, when properly or even fairly laid, has failed either on account of weakness or inability to withstand the chemicals of the sewage.

The mortar used in making pipe here has been composed of 2 parts of either Newark and Rosendale, or Hoffman's, or Norton's Rosendale cement and 3 parts clean sand. The latter preferably of various degrees of fineness from the very finest to the size of one's finger end, in such proportions that the finer fills all the chinks in the latter, as the cement finally coats each particle and fills all remaining spaces.

It has been the experience of the maker that a larger proportion of cement inclines the pipe to season crack and that a smaller proportion makes weaker pipes, with more difficulty in removing the moulds.

It is important that the materials be thoroughly mixed dry and that the mortar be well rammed in the moulds.

It is also important that the right amount of water be used. Every particle of cement and sand should be wet, but the mortar should be stiff enough so that the rammer should bring up solidly on it and press it firmly together instead of displacing it horizontally.

The cores are usually drawn almost immediately after the pipe is finished and in good weather the cases removed in about half an hour. The pipe is kept under cover about two weeks, and then preferably put out into the sun and air and well wet every day. This wetting is particularly important.

A curious fact is that an old pipe will absorb less water and is heavier than a new one. Will some reader explain it?

The pipes are considered ready for ordinary use six weeks after they are put out.

They are sometimes used much greener and may be so used safely if carefully handled and properly laid. When necessary to use them very green, Portland and Rosendale cement is used; one part of the former to two of the latter. A large proportion of Portland makes the mortar set slowly, at first making it difficult to remove the moulds.

The above details are furnished by Wm. D. True, Esq., of this place who has made most of the pipe used here the past ten years.

Will some reader tell us how much pressure a sewer pipe ought to be able to sustain in order to withstand any pressure liable to occur in actual use?

Respectfully

CHAS. E. CHANDLER.

The Nashville, (Tenn.) Water Works.

The following report was presented to the Board of Public Works July 3d.

TO THE BOARD OF PUBLIC WORKS AND AFFAIRS, Nashville—Gentlemen: I was requested by you on June 11, to proceed to make such tests and examinations as should determine whether the cause of the present inadequacy of the city water supply existed at the water works.

The report of such examination is herein respectfully submitted.

From the shortness of the time at command, and the absence of facilities, the results are, in some features, only approximations. The tests determined on, and fully carried out, were as follows:

1. A leakage test of the city reservoir.

2. A test of the delivery of the Worthington pumps into the reservoir during a specified length of time.

3. A measurement of the coal consumed under the boilers, and of the water thereby evaporated during the above interval.

4. Records of the steam pressure, temperature of feed water, number of strokes made by the pumps, and height of suction and discharge lift.

DESCRIPTION.

The tests were executed during the nights of June 25 and 26, and following days. The water in the reservoir was allowed to fall considerably below the top of the wall; the valves leading into and out of the reservoir were then closed and the rate of leakage determined; the reservoir being still shut off from the city, the pumps were then started and delivered into the reservoir during a specified time and the rate of delivery determined. The pumps were then stopped and the rate of reservoir leakage at the new height of water determined.

The delivery as well as the leakage was found by gauging the height of water in the reservoir, using a graduated rod reading to one one-thousandth of a foot, and by knowing the area of water surface from an accurate survey made for the purpose by Capt. Mead, City Engineer.

The coal used was weighed and the percentage of ash estimated.

The feed-water was measured by a two-inch Crown water meter between the feed-pump and the boilers.

The furnaces, boilers and pumps were brought to a settled running rate before the registry of coal, feed-water and reservoir delivery were commenced, and were brought to the same condition at the close of the test.

Readings of the water-meter and boiler pressure were made at intervals of fifteen minutes by Mr. E. E. Barnard, and a count of the speed of the pumps and record of water and steam pressures at the pumps was made at the same instants by Mr. L. M. Donaldson.

The reservoir gauge was read at every alternate pump reading.

The height of the river at time of the test was marked, and the distance below the pumps afterwards levelled, as well as the distance to the point of entry at reservoir. The coal used was Helena small nut, dry and free from small slack. On making a comparison of gauges with the United States standard gauge at the custom-house after the tests, the Worthington water-gauges were found to be so irregular in their action that their readings during the test were abandoned and the theoretical resistances computed. The absence of such a vacuum gauge on the suction pipe rendered such a computation necessary for that also.

DATA.

Height of water in river at test, 114,676 ft., city datum; height of center pump cylinders, 131,611 ft., city datum; height of center entry spout at reservoir, 288,996 ft. city datum; height of water in reservoir at 11.39, beginning at first leakage test, 278,911 ft., city datum; height of water in reservoir at 12.30, ending first leakage test, 278,619 ft. city datum; height of water in reservoir at 12.45, beginning pump test, 278,390 ft., city datum; height of water in reservoir at 2.30, ending pump test, 280,980 ft., city datum; height of water in reservoir at 2.45, beginning second leakage test, 281,118 ft., city datum; height of water in reservoir at 3.15, ending second leakage test, 280,974 ft., city datum; area of reservoir at level water during test, 23,365.82 sq. ft.; temperature of water during test 81° Fahrenheit; weight of one cu. ft. of water at 81° Fahrenheit, 62.180 lbs.; weight of one United States gallon of water at 81° Fahrenheit, 8,3136 lbs.; weight of coal consumed during test, 4,645 lbs.; percentage of ash and timber (estimated) 12½ per cent.; weight of combustibles consumed, 4,064 lbs.; weight of water evaporated during test, 26,779.58 lbs.; temperature of boiler feed-water, 81° Fahrenheit; average boiler pressure during test, 72 lbs. per sq. in.; corresponding temperature of steam 318° Fahrenheit; weight of water evaporated per pound combustible from 81° to 318° 6.6

lbs.; weight of water evaporated per pound combustible from and at 212°, 7.7 lbs.

Number of pumps, Worthington Compound Duplex, 4; number of cylinders each pump, 2; diameter of pump cylinders, 16 in.; diameter of pump piston rods, 2¼ in.; length of plunger stroke, 18 in.; displacement for each northward stroke, 15.667 gallons; displacement for each southward stroke, 15,285 gallons; average single stroke made by one plunger bluff pump, 200, or 64.75 per minute; average single stroke made by one plunger bluff pump,—201—67.50 per minute; average single stroke made by one plunger river pump, 205—66-75 per minute; average single stroke made by one plunger river pump, 206—68.25 per minute average double stroke made by all plunger pumps, 267.25 per minute; number of minutes duration of test, 105; total number of double strokes during test, 28,061.25; total number of gallons theoretical displacement, 868,551.8.

	Feet
Hydraulic head due to suction lift	16.935
Hydraulic head due to velocity of entry	.052
Hydraulic head due to strainer and check valve (estimated)	.200
Hydraulic head due to change velocity at river pumps	.0.6
Hydraulic head due to 4—90° bends (each pump)	.520
Hydraulic head due to friction at velocity of 1.65 feet per sec	.062
Hydraulic head due to resistance of pump (estimated)	3.000
Total hydraulic head on suction side	20.785
Hydraulic head due to lift of force main	157.385
Hydraulic head due to resistance of pump exit (estimated)	2.000
Hydraulic head due to 4—90° bends, each pump	.520
Hydraulic head due to friction at velocity of 1.6 feet per sec	.200
Hydraulic head due to check valve and entry valve	.350
Total working hydraulic head	181.240

RESULTS.

Leakage of reservoir into ground or pipes per 24 hours, 1,324,600 gallons; delivery of pump (corrected for leakage) per 24 hours, 7,532,300 gallons; water lifted by pumps during test,4,566,070 lbs.; working head lifted through, 181,24 ft.; foot pounds represented by above factors, 827,554,563, ft. lbs. duty of pumps per 100 lbs. combustible, assuming boiler to evaporate 9¼ lbs. water per lb. combustible from and at 212° Fah., 21956870 ft. lbs.; boilers actually evaporated during test per pound of combustible from, and at 212°, 77 lbs. water; boilers evaporate for each horse-power developed by pumps 64 lbs. water; water delivered during test, shown by reservoir gauging, 549,229 gallons; water delivered during test, shown by displacement of plungers, 868,552 gallons, showing a "slip" of 36¾ per cent. Pumps running at test rate would deliver, per twenty-four hours, without slip, 11,900,000 gallons; or, running at test rate would deliver per twenty-two hours, with 9 per cent. slip, 10,000,000 gallons.

The rate of the pumps during the test was not above the usual running rate, nor up to the average rate indicated by the builders, which is seventy strokes per minute.

The coal consumption during the test was not out of proportion to the regular consumption, as the test rate was 723.9 bushels per 22 hours, while for June the rate has been 751.3 bushels per 22 hours.

DEDUCTIONS.

From the above results it will be seen:

1. That the loss from the reservoir is about one and one-third million gallons daily, either wholly or in part into the ground and hence wasted.

2. That the Worthington pumps are pumping about three-fourths of their rated capacity, although they are running at a speed sufficient, under proper conditions, to pump more than that rated amount in twenty-two hours—the average daily run—even allowing a liberal loss from "slip."

3. That the duty developed is about one-half what should be expected of this style and size of pumps. No responsibility for this can be thrown on the boilers, as the computed duty was based on an assumed rate of evaporation, one, however, which is being realized by several of the leading boilers and guaranteed by their makers.

4. That the boilers (new battery) are accomplishing four fifths of this rate of efficiency.

5. That the probable cause of the inefficiency of the pump exists on the side of the suction, either from abnormal resistanceto the passage of the water, possibly by a stoppage of the strainer, or by air leaks, which reduce the vacuum and prevent the cylinders from filling.

I was also requested by you to offer such suggestions looking towards the improvement of the water deficit as should seem pertinent. As the present pumping system will doubtless soon be superseded, I shall recommend no radical change at this time, yet as the present needs of water consumers must be supplied, and as that portion of the current expenses of the water-works which is proportional to the water pumped amounts to $11 per million gallons, it is clearly advisable and economical to take prompt action in increasing the efficiency of the present supply system, even to the extent of making some considerable outlay.

I therefore make these suggestions:

1. That an examination be made of the bottom and sides of the city reservoir in order if possible, to discover and remedy the waste therefrom.

2. That a vacuum gauge be supplied for the suction pipe and if this indicates a pressure greater than that given in any computed suction resistance, I would recommend an examination of the strainer at the end of the suction pipe and a proper cleaning of the same, if necessary. If, however the gauge should show an unstable vacuum, I would recommend a thorough examination of the suction pipe from pump-chamber to low-water mark, for the purpose of discovering air-leaks.

3. That registers be attached to each of the Worthington pumps, and that the engineers be directed to record the number of strokes made by each pump as well as the reading of the reservoir gauge at regular six-hour intervals. This is important in order to know the quantity of water being supplied to the city.

4. That a heater be constructed to use the exhaust steam in heating the feed-water for the boilers. I have estimated that, at the present rate of coal consumption, such a heater by heating the feed-water from the mean annual temperature of the Cumberland 60 F. to 190 F. would affect a saving of coal amounting to $8 a day, and would moreover greatly improve the behavior of the boilers, and materially lessen the injury to the same from strains caused by cold water being pumped into the hot boiler shell.

5. That Superintendent Reyer be given authority to carry out his plan of a properly arranged system of evaporative tests for such coals in the Nashville market as will be placed in competition for the coming year's supply, and that the contract be made on the basis of the results of such competitive tests and the prices tendered.

6. That a city ordinance be passed, which shall constitute as a misdemeanor, punishable by a water fine.

1. The permitting water to run, when not used, from any hydrant, water-tap, basin, bath, urinal or closet, connected with the city water supply, with a scale of fines graduated to the rate of discharge and expressed in terms of the size of the opening and the depth below the reservoir.

2. The permitting water to waste through any leakage or defective joint or water fixture connected with the city water supply.

7. That a permanent corps of water inspectors be maintained whose duty it shall be regularly to inspect the water connections of every premises connected with the city water supply, and to record and report violations of the above ordinances to the proper city officials for assessment and collection of fine.

My reasons for the two last suggestions are that it would, in my opinion, effect a saving of water far in excess of the cost of the inspection, and would in no way interfere with the legitimate use of water.

At the average elevation of the city the continued running of water through 350 openings one-eighth inch in diameter, or eighty openings one-fourth inch, or eighteen openings one-half inch, or five openings one inch in diameter, would waste a million gallons daily.

The city must either supply this loss at an extra cost of $11 per million gallons or some one else must do without water, usually the latter.

I am confident that nearly one-half of the water rent to the city from the reservoir is wasted. Fifty gallons per day per capita of the total population is a liberal supply to use, indeed, to use lavishly, but not to waste, for all purposes, including domestic use, fountains, stables, streets, manufacturing and fire purposes. Assuming Nashville's population to be 60,000, this would require three million gallons, while in fact certainly five million and probably six million gallons pass the reservoir daily to the city.

I am indebted to Superintendent Reyer for all possible facilities placed at my disposal and assistance rendered in conducting the tests; also for the same to W. H. Perry & Co. agents for the Worthington pumps. I am, sirs, yours, respectfully,

OLIN H. LANDRETH.

Specifications for Egypt Turnpike, Auglaize Co. Ohio.

The line of said pike commences at Minster in said county, and runs thence west three miles to St. Joseph Church. having four branches; the whole aggregating 5,53 miles.

The Roadway will be opened to a width of twenty-five feet on each side of the center line, and cleared of all obstructions within the area to be used in making the grade and ditches; trees and stumps must be grubbed from cuts and side ditches, and cut off even with the ground in fills.

The Line of the road is marked by stakes set twelve feet to the left of the center as you go in the direction of the numbers.

The Road Bed will be constructed according to the grade line represented on the profile of said road. The form of the roadbed will be twenty-four feet wide,crowning in its transverse section, with the center eight inches higher than the outside or hip; at culverts and bridges the cross section shall be level, and slope to the usual form of twenty feet from bridge or culvert. The Freiburg and Hanover branches will be graded forty feet wide with the center one foot higher than the sides.

Side Slopes on embankments will be two to one from hip of grade to bottom of ditch, which in no case shall be less than two feet below grade. On fills of more than two feet, side slopes will be one and a half to one. Slope in excavation and back slopes of ditches must in all cases be one to one.

Side-ditches through cuts will be one foot deep and three feet wide, in other cases they will be evenly constructed so as to make complete drainage to natural water-ways. County, township or private ditches, which require filling to construct the grade, must be reconstructed to their full depth and capacity.

Approaches from all intersecting roads must be graded twenty feet in width, with a slant of not more than one in four, and graveled with ten cubic yards of gravel spread to suit each particular case.

Shrinkage.—All embankments must be built high enough above grade to allow for settlement—the amount to be determined by the engineer in charge of the work.

Culverts will be laid up dry; walls two feet thick, built of good sized and well shaped quarry stone, six to eight inches thick, two feet wide having parallel beds. Trenches for masonry must be excavated one foot larger each direction than the wall to be built, and not filled around the wall until the same has been inspected and accepted.

Culvert Wood-work will be built as per plan and specifications on file.

Coping for Box Culverts must be eight inches thick and long enough to extend one foot on each wall. No space in joints to exceed one

inch, and exposed stones at the ends of culverts to be squared and pitch-faced.

Pipe Culverts must be in place and protection walls completed before grading. No logs, fence-rails or other timber to be left within one foot of any pipe, and earth must be firmly tamped under the sides thereof. Unless otherwise directed, the pipes will be laid with the bottom level with the side-ditch at that point. Each end of these pipe-culverts will be protected by a stone wall, laid up dry, on each side thereof, two feet square, set six inches below the lower side of the pipe, stand one inch in the clear from the sides, and the same distance from the top thereof; on top of these walls will be placed a stone two feet wide, three feet long and six inches thick—the walls and cap to stand flush with the pipe. None but first class vitrified Sewer Pipe will be used.

Bridge Masonry—Pits for foundations will be sunk to a depth satisfactory to the Engineer Foundation walls will consist of large stones, squared, jointed and bedded; one third of the, same shall extend through the wall. The stones are to be well-adjusted to give a uniform bearing, and carried up to a line, as shown on the plan, above which line the wall will be more accurately faced.

Number two Bridge stone will be used, laid in cement in regular courses, level and true to line. At least one-fifth of the stones in each course shall be headers extending through the wall. No stretcher shall have a width less than its thickness, nor a length greater than four times its width. No bond less than fifteen inches will be allowed in the face of the work. All stones in face must be pitched to a true line, and stones at the end of each course must extend entirely through the wall and be pitch-faced on the exposed end.

Joints in the face of the wall must not exceed three-fourths of one inch in thickness, and the stones used in the face must be sufficiently dressed to insure this result.

Batter on front and wing walls will be one in ten to level of bridge-seat, above which, the wings will be vertical. The top course of main wall will be eight inches thick, and project three inches, the whole length of the work; the upper face to be dressed to the same true level.

At the angles in the face of the work, and at the corners of the wing-walls, there will be a one inch draft neatly cut.

Coping of wings will project three inches all around; the top to be rough pointed, the under side dressed to lay three-quarter inch joints; the end dressed full width and depth to lay three quarter inch joints. Mortar joints will be neatly pointed with cement.

The mortar will be composed of the best Louisville cement and coarse, sharp, clean and well screened sand, in the proportion of one of cement and two of sand; to be thoroughly mixed, dry, and after wetting, shall be quickly and thoroughly worked, and used at once to prevent partial setting before it is laid in the work.

Canal Bridge will be a Wood Truss, sixty-five feet long, sixteen feet roadway, built as per plan and specifications on file. After not less than eighty rods of grade, including culverts and sewers have been completed a layer of good, clean gravel will be furnished and paid for by the contractor, and laid on the grade in the center, sixteen feet wide, fifteen inches deep in the center and nine at the sides, except at bridges and culverts it will be eighteen feet wide, a plane from side to side and resuming the usual shape at twenty feet from bridge or culvert. The coarse gravel must be raked forward and spread upon the center of the road-bed; no stone over two inches to be left within six inches of the surface. The surface of the gravel will be rounded parallel with crown of grade and give the depth required. Contractors are required to keep the road in repair until finished and accepted.

The Engineer in charge of the work may from time to time direct any change in the plan during the construction of the road, that is in his opinion needed, and if there will be material increase or decrease of cost by reason of such change, an increase or decrease of pay will be made. Contractors will be required to commence work on or before the first of August and employ a sufficient force to insure the completion of the masonry on sections one, three and six by October 1st, next, and the remainder June 1, 1885; grading and graveling on sections one, three and six by November 1, 1884, and the remainder November 1, 1885.

Proposals for grading and graveling will include clearing, chopping, grubbing, grading ditching and graveling. Bids for sewer pipe include furnishing, hauling, setting, furnishing stone for and building protection walls. Bids for stonework include furnishing stone and other materials, excavating trenches and completing the work. Bids for bridges will also include furnishing all material and labor to finish according to specifications. Should the contractor fail to comply with the terms of his contract, he forfeits the same and the Commissioners and Engineer may relet the job. Payment will be made in cash upon monthly estimates of the Engineer, reserving ten per cent. until the completion of the work.

SAMUEL CRAIG, Engineer.

The above pike was sold, July 8th to H. Herkenhoff, of Minster, Ohio, at the following prices:

Grade and Gravel	$14,000
12 inch Sewer Pipe	0.60
18 inch Sewer Pipe	1.00
Dry Masonry	4.50
Bridge Masonry	5.00
Coping per square foot	0.15
Wood top on Culverts	1.95

The Canal bridge was sold to Frank Thieman of the same place for $5.25 per foot.

Impure Well Water.

The Board of Health's condemnation of the use of New York city well water by mineral water makers was anticipated by nearly two years by Mr. Carl H. Schults, who wrote in October, 1882:

"It is not safe to use well water except where it is proved by chemical analysis not to be injurious. These waters should not be used for the purpose of manufacturing beverages, because they are too strongly impregnated with mineral matter. Croton is entirely pure in this regard, and the organic matter found in it can be absolutely removed. It is a practical impossibility to manufacture a safe and correct mineral water of Manhattan well water, because they already contain an excess of mineral substances, which cannot be taken out except by the expensive process of distillation. They are used on account of their good appearance, only for cheap mineral waters, which contain more solid indigestible matter than some mineral springs. Dug wells are invariably contaminated, but they are rapidly disappearing or being abandoned.

LABORERS in Mexico fare hard. Tirty cents a day is the common rate of wages, and for that the natives are content to perfrom the heaviest labor. Farm work, mining, factory labor and domestic service are all alike paid low. The custom of making loans to laborers to be repaid by work is common, and tends materially to prevent their social advancement. The large factories are thus enabled to retain their hands as long as they desire. The latter are not allowed to leave their employment until they have paid their debts, and as that is generally impossible out of wages which are barely enough for support, the debtor continues a virtual slave to his life's end.

WATER.

TO WATER-WORKS OFFICIALS.

Croes' Statistical Tables of American Water-Works is the most complete Compendium of Information concerning American Water-works in print. It was published one year ago, and is for the benefit of parties engaged in the Construction, Official Management, or Mechanical Operation of Water-works. If there is any such person, Civil Engineer, Contractor, President, Secretary, Superintendent, or Mechanical Engineer of any Water-works in America, who has use for the book, and who has not got a copy already, we will be pleased to send it to him on receipt of one *five cent postage stamp*, with which to prepay it to his address.

NEWARK, Ohio., is agitating the question of Water-works.

THE Detroit Water Commissioners are replacing their wooden pipes with iron

LANSING, Mich., is intending to put in Water-works either by granting a franchise to a company or otherwise. Would prefer to let a company have the right, providing a fair rate can be agreed upon for service, etc.

THE fact that shutting down the gates of the Central Park Reservoir only one eighth of an inch, recently, caused numerous complaints from consumers, shows to what extent the Croton Aqueduct is taxed in the effort to supply the demand for water of New York's rapidly increasing population.

FIVE large artesian wells in the suburbs of Denver are pouring 200,000 gallons daily into the Platte river and wasting the same. As they materially reduce the head of other wells whose water is of great use in manufacturing, it is suggested that water-works company is trying to get a corner in that article.

THE contracts for the construction of the Weymouth, Mass., Water-works were awarded July 9th. The cast-iron pipe 3900 tons to A. H. McNeal, of Burlington N. J. All else to W. C. McClallan, of Chicopee, Mass. The whole amounts to $250,000. The engineer's estimate of the cost was $296,400.

DALLAS, TEX., is suffering from a water famine. The supply is derived from a natural reservoir known as Browder Springs. A neighboring stream overflowed its banks during recent heavy rains and deposited so much mud in the reservoir that the supply was totally cut off. A pump has been put in, which will supply 1,000,000 gallons of river water per twenty-four hours.

BROCKTON, Mass., has been having trouble with its water supply in the matter of quality. The supposed cause is the large amount of surface water from recent rains and a disturbance of the circulation by the addition of 5000 ft. of new pipe. A $5,000 filter failed to work satisfactorily and is lying unused while the impure water at the bottom of the reservoir is drawn out through a 12 in. gate. The supply is taken at a point 6 ft. from the bottom.

BELTON, July 10.—The final test of the water-works was made to-day. The first test was eight streams thrown upon four hydrants, at the four corners of the square, to a height of 75 ft. from the stand-pipe pressure alone. The four streams were thrown from the same places to an altitude of 100 ft. with the same pressure. After this the stand-pipe pressure was cut off and the direct pressure put on, and two streams were thrown 140 ft. high.

NEWS OF THE WEEK.

Railroads and Canals.

A TEMPORARY suspension of work of the Georgia Pacific extension to Columbus, Mississippi, took place July 3d.

THE work on the Cripple Creek extension, an important branch of the Norfolk and Western Railroad of Virginia, has been suspended.

THE extension of the Lexington branch railroad from Independence to Kansas City is progressing rapidly.

THE extension of the Gulf, Colorado and Santa Fé through Indian Territory, will involve the construction of from 250 to 300 miles of road.

THE Pittsburg, McKeesport and Youghiogheny Railroad will issue $1,000,000 worth of bonds. The proceeds to be devoted to extension.

THE New Orleans Railway Company has closed a contract for the building of a line to Shelby, a point across the river from Arkansas City a distance of about 15 miles.

THE bill granting right of way through Indian Territory to the Southern Kansas railroad, a branch of the Atchison, Topeka and Santa Fe., has become a law. The Indians have signified their intention of vigorously contesting its execution, claiming that it is unjust and injurious to them.

PRINCE BISMARCK has ordered the engineers to hasten the preparation of the plans for a canal from the Baltic to the North Seas. The necessary credits for the construction of the canal will be asked of the Reichstag at its coming session.

CONTRACTS were awarded for the first 10 miles of the Bremond Narrow Gauge to start from Shreveport, La., to M. D. Collins and J. D. Lynch, who have just completed contracts on the Vicksburg, Shreveport and Pacific. Work has commenced. Other contracts will be given out as soon as the preliminaries are arranged.

TRACK-LAYERS on the Canton, Aberdeen and Nashville Branch of the Southern Division of the Illinois Central have reached the crossing of the Mobile and Ohio Road at West Point, Miss., seventeen miles north east of the late terminus at Starksville, and seventy-two miles from the starting point of Kosciusko. The grading is substantially finished to Aberdeen, about eighteen miles further, and track-laying is progressing rapidly.

THE work of construction on the Pine Bluff and Swan Lake railroad has commenced. It will diverge from the Texas and St. Louis railroad at Waldo, near Rob Roy and then proceeds in a generally easterly and southeasterly direction by way of Lake Dick, Astor Point, New Gascony and Swan lake. This line, which passes through the richest cotton section in the Arkansas Valley, will be completed by January 1st.

THE nineteen branch lines of the Union Pacific have a total mileage of 3,000 miles.

THE Iron Gate, the famous rapid or cataract of the Danube, is to be removed. The Hungarian Government has appropriated 10,000,000 florins for the purpose, and a canal wide enough to admit of the towing of vessels will be opened. The work will take six years.

THE engineers of the Pennsylvania Schuylkill Valley Railroad have completed their surveys between Reading and the Blue Mountain Gap, two miles north of Hamburg. The maps, outlines, etc., of the several routes under consideration are now in the hands of the management, and as soon as a definite route has been decided upon, proposals for the immediate construction of the road will be invited.

WHEELING, West Va., July 10.—A certificate of incorporation was issued July 10th, to Henry M. Hoyt, B. K. Jamison, J. W. Jones, J. Dickinson Sergeant, Thomas Graham, and George Biddle, all of Philadelphia, who constitute a company formed for building the West Virginia and Ohio Railroad from Pocahontas, Tazewell County, Va., across West Virginia to the Ohio River at the mouth of the Big Sandy.

WILKESBARRE, Penn., July 14.—The Vosburg tunnel, on the Lehigh Valley Railroad, 25 miles north of this place, is rapidly approaching completion. Yesterday was a gala day in Vosburg, the tunnels from opposite sides of the mountain having been blasted through at 4 o'clock in the morning. The tunnel is 3,865 ft. long, 21 ft. high, 28 ft. wide, and runs under a mountain 365 ft. high. It saves 5½ miles in distance, and was begun a year ago by Engineer Owen.

THE French Minister of Marine reports the following mileage of railroads in French colonies in 1882: Martinique, 304 miles; Guadaloupe, 207 miles; Reunion, 77 miles; Senegal, 10 miles. The railroad in Senegal (Africa) is under construction for 151 miles further and so far advanced that it will probably be opened by the end of this year. It will reach the navigable part of the Niger. A railroad is also under construction in Cochin China.

IT is proposed to have a universal exhibition of railroad material at St. Etienne, in France, next year. St. Etienne is a city of nearly 100,000 inhabitants in Southeastern France, some thirty miles southwest of Lyons. It is proposed to have tracks in the form of an immense figure 8, in which different systems of iron substructure, joints, chairs, rails, switches, signals, etc., shall be employed and tested.

THE Milwaukee, Lake Shore and Western Railroad Company has its track laid to town 46, ran e 44, and the right of way is cut out to within two or three miles of Sunday Lake. The company have a force of over 1500 men at work, and it is expected that the track will be laid to the Montreal River by August 1st, and to Ashland and Washburn by the first of January. As soon as possible spurs will be laid from the main line to the different promising mining locations.

THE capital stock of the Triple Thermic Motor Company, which was incorporated on the 15th by a certificate filed in the County Clerk's office in this city is $25,000,000, divided into 250,000 shares of $100 each. It's corporators are Aaron H. Burlingham, of East Chester, N. Y.; Andrew J. Davis, Joseph Whitney, George H. Brennan, and Charles L. Campbell, of New York; Stephen B. Puffer and Wilbur S. Littlehale, of Lowell, Mass., and Edwin E. Wise, of Chicago. The company will manufacture triple thermic motors.

LITTLE ROCK, Ark., July 13th.—The Gurdon and Okolona Railway has filed the field notes and plans of their preliminary survey. The line will run from Gurdon, on the Iron Mountain Railroad, to Okolona, in Clark county, a distance of 14 miles. The company have sufficient paid up stock to complete the earthwork and bridging, and are now making arrangements for iron. They intend to commence construction immediately and have the line in operation by the 1st of November to South Fort creek.

THE Croton Aqueduct Commission on the 16th, voted to build the new aqueduct at a grade 10 ft. higher than the one proposed. The object of this change is to enable the commission to make use of storage reservoirs above the Harlem, which the grade formerly adopted would not permit. The commission also received same day the last of the property maps, which includes the land between the Pocantico River and Ashford Station. Legal steps for acquiring the property will at once be taken. It is expected now that the first shafts for excavations will be down by the latter part of October next.

THE first shipload of railway plant for Suakim left Woolwich Arsenal recently.

THE Government of India, which controls and operates the greater part of the railway system of that country, has determined to adopt iron freight cars, and it is advertising for contracts to furnish 1,000 cars made of that material. The specifications require a 25 ft. open car, resting on two trucks.

THE SUEZ CANAL.—The gross revenue of the Suez Canal Company in 1883 amounted to 2,740,934*l*. After provision had been made for working expenses, statutory allocation to the reserve, interest at 5 per cent. per annum upon capital, etc., a balance of 1,434,542*l*. remained available for the payment of a further dividend. The total distribution upon each 20*l*. share for 1883 has been fixed at 3*l*. 11s. 11d. This is equal to about 17¾ per cent. per annum. In consequence of the appointment of some additional English directors the number of members of the council of administration has been carried from 14 to 32.

THE St. Joe, Mo., and Eastern Railroad Company has filed articles of association, the following gentlemen being directors: J. W. Bailey, Charles McGuire, W. R. Johnson, F. M. Posegate, J. W. Boyd, O. A. Sandusky, R. H. Fawcett, St. Joe; J. P. Richardson, O. W. Noland, Daniel Clouser Halleck, K. M. Woods, Jr., J. Barnard, Smithville. The road will run from St. Joe, near Lake Contrary, thence through Halleck, Camden Point and Smithville, a distance of forty miles. It has been estimated that it can be built and equipped for $6,000 a mile, necessitating the raising of $240,000. Provided that work is commenced as expected by Sept. 20th, the road will be completed in a year.

ONE of the most remarkable instances of the transmission of power by electrity is that presented by the electric railroad in one of the main cross-cuts of the Oppel colliery, Saxony. This crosscut is 2,362 feet long, and is the outlet for the coal mined in the vein, the quantity delivered to it being 600 mine cars per day of sixteen hours, each car weighing loaded, 1,594 pounds. A train of 15 cars is moved at a speed of from 7 to 10 feet a second, the steam, engine at the mouth of the shaft making from 225 to 259 revolutions during the run, lasting from three and one-half to four-and one-half minutes, through the crosscut. When doing this amount of work, the steam engine delivered 11.2 horse-power; or, assuming the friction of the engine's gearing to have occasioned a loss of twenty-fivd per cent. the power actually transmitted by the electric current to the locomotive was 5.22 horse-power, or 46.6 per cent. An estimate of the cost shows that there are probably many cases in which the transmission at power by electricity would pay well.

THE *Age of Steel* has published over ninety letters from leading manufacturers tending to show that the business depression is not as bad as generally supposed.

THE new dynamite gun, so called, is really an air gun. The dynamite is in the bomb discharged. The experimental gun was of 4 in. bore and 40 ft. in length. An air pressure of 500 lbs. was used which threw a shell containing 16 lbs. of dynamite a distance of a mile and a quarter.

THE Wyoming Development Company of Colorado, has in hand an irrigating canal which will cost 500,000. It runs through a three quarter mile tunnel which will alone cost $125,000. It is expected that 60,000 acres of land will be reclaimed.

A COMMITTEE appointed to investigate the discharge of sewage into the Thames river has reported that liquid entering at Barking is transported many miles up river in the face of the powerful descending stream of land-water.

THE Delaware and Chesapeake Improvement Company are working out the contract for dredging a channel 300 ft. wide and 10 ft. deep at low water, across the bar in the Delaware river at Philadelphia. They are receiving 22½ cents per square yard, and are dredging to the depth of 12 ft. to ensure the depth of 10 ft. after the action of floods and tides. The work will be finished by the first of August.

EXPERIMENTS are being made both in this country and England, with a view to determining the relative effectiveness of gas, oil and electricity in lighthouses. Gas gives a light of great penetrative power but with much heat. Electricity is very effective in clear weather, but is apt to flicker and fails to penetrate through a fog.

THE board of Public Works of Minneapolis, recently awarded the following contracts: For paving St. Peter Street with granite, William Forrestal, $39,300; for paving with granite Broadway and Mississippi streets, Andrew Jacks, $28,800; for grading Oakdale Street, Joseph W. Smythe, $14,445; for construction of sewer on Oak Street Stockton and Lindquist, $1,751.25; for same on Jackson Street, J. W. Doherty, $1,093. At the meeting, the following contracts were given to the City Attorney to be drawn up. Construction of sewers on Seventh Street, from Jefferson to View, Stockton and Lindquist, $18,594; same on Western Avenue, from Seventh to Von Minden, J. W. Doherty, $369; for grading Locust Street from fourth to Seventh, Patrick Nash, $1,775; same with Josette Street from Dayton Avenue to Fuller Street, Peter Thantholt, $2,965, and same with guttering Rondo Street from Rice to 425 ft. west of Louis, Carl Boher and Henry Justus, $2,400.

Abstract of Proposals received and opened by Major A. Mackenzie, Corps of Engineers U. S. A., Rock Island, Ill. at 2 P. M. July 3 1884, for construction of four (4) dump boats for use at the Des Moines Rapids Canal.

No.	Name of Bidder	Residence	Delivered at Keokuk, Ia.	Delivered at Points named below	
1	Alfred Cutting,	Metropolis, Ill.,		Metropolis, Ill.,	9100 00
2	Hansen & Linehan,	Dubuque, Iowa,	7844 00	Dubuque, Iowa,	7844 00
3	Edmund J. Howard.	Jeffersonville, Ind.	.....	Jeffersonville, Ind.	7100 00
4	D. S. Barmore & Son,		.....		9500 00
5	Van Sant & Edwards,	Le Claire, Iowa.	5800 00	Le Claire, Iowa,	5700 00
6	H. S. Brown,	Quincy, Illinois.	6000 00	Quincy, Ill.,	5950 00
7	Diamond Jo Line Strs.,	Dubuque, Iowa.	6500 00	Dubuque, Iowa,	6030 00
8	M. H. Moore,	" "	7300 00	" "	7100 00
9	Allen & Blaisdell,	St. Louis, Mo.,	7300 00	St. Louis, Mo.,	7200 00
10	Luther M. Emerson,		.....	" "	6080 00
				Quincy, Ill.,	5624 00
11	J. Eckhardt & Son,	Davenport, Iowa,	6900 00	Davenport, Iowa,	6800 00

THE Grand Trunk Railroad of Canada has under discussion a project to drive a tunnel under the St. Clair River about 1½ miles below Sarnia.

Miscellaneous.

CHICAGO is to have a new school building to cost $75,000. The plans have been prepared by Architect Flanders.

THE British trade in iron rails has become almost extinct. During the first four months of last year the export of iron rails was 11,057 tons. For the same period this year only 4,149 tons were exported. The export of steel rails for the same periods were 246,536 and 171,355 tons respectively.

A NEW use has been found for glass. The pulleys upon which the cables run in systems of cable railway are to be made of it. The object is to reduce the friction and consequent wear. The pulleys are not solid glass but consistion of a skeleton wheel of iron surrounded by a glass tire and running in glass bearings. Mr. J. J. Hardin of Chicago is the inventor and the firm of Atterbury & Co., of Pittsburg have gone into the manufacture.

THE award of contracts for furnishing trap rock blocks for use in inverts of large sewers in Washington, D. C., was made recently. The Washington Granite Company secured the contract for furnishing 400,000 at $44, $47 and $48.50 per 1,000, and the Richmond Granite Company was awarded the contract for 150,000 at $43.75 and $44.25.

CONTRACTS FOR SEWER PIPE.—The District Commissioners of Columbia awarded contracts for furnishing terra cotta pipe for sewers as follows:

To the Akron Sewer Pipe Company, 12,600 feet of 15 inch pipe, at $3,780; 6,000 feet of 21 inch pipe, at $5,100; 7000 feet of 24×6 inch branch pipe, at $9,900, and 700 feet of 24×6 inch pipe at $1,540—total, $20,320.

McMahon & Porter, 20,000 feet of 12-inch pipe, at $4,800, and 10,500 feet of 18 inch pipe, at $5,250—total $10,050.

Junction blocks: Potomac Terra Cotta Company, 16,000 feet of 12 inch, at $5,680; 3,000 18 inch, $1,440; 1,600 21 inch, at $800; 1,000 24 inch, at $1,100; 1,000 12×6 inch, at $400; 100 18×6 inch, at $1,120, and 500 21×6 inch, at $750—total, $40,840. There were six bidders in this class.